2015

Development and Evaluation of an Objective Method for Forensic Examination of Human Head Hairs Using Texture-Based Image Analysis

Allyce S. McWhorter

Development and Evaluation of an Objective Method for Forensic Examination of Human Head Hairs Using Texture-Based Image Analysis

Allyce S. McWhorter

Thesis submitted to the
Eberly College of Arts and Sciences
at West Virginia University
in partial fulfillment of the requirement
for the degree of

Master of Science
in
Forensic and Investigative Science

Thirimachos Bourlai, Ph.D., Co-Chair
Patrick Buzzini, Ph.D., Co-Chair
Tina Moroose, MS

Department of Forensic and Investigative Science

Morgantown, West Virginia
2015

Keywords: hair, texture, image

ABSTRACT

Development and Evaluation of an Objective Method for Forensic Examination of Human Head Hairs Using Texture-Based Image Analysis

Allyce S. McWhorter

In response to criticism of traditional forensic methods of human head hair examination, the goal of this study was to develop and evaluate an objective method using texture-based image analysis. 120 individuals, including 20 from six different maternal groups, were sampled and their hairs evaluated using the developed method. Different variables were evaluated to develop the most efficient method to increase intra/inter ratio, as well as the percentage of well-classified hairs. The variables included different microscope systems, objective lenses, number of hairs examined per individual, hair shaft regions, focus methods, and normalization filter techniques. Statistical analyses included one-way analysis of variance, agglomerative hierarchical clustering, and classification trees. A tested method based on the combinations tested and a theoretical method based on evaluation of the performance of each variable were determined. The tested method revealed increased ratio of inter- and intra-variability and percentage of well-classified hairs when the reference population is decreased. The method also revealed percentages of well-classified hairs above 90% when comparing an individual to other members of the same maternal group, a comparison that would fail to differentiate if tested with mitochondrial DNA analysis. Future testing of the theoretical method, as well as further testing of maternal groups and population size, will need to be done to verify these results.

ACKNOWLEDGEMENTS

I would like to thank Dr. Patrick Buzzini, Dr. Thirimachos Bourlai, and Tina Moroose for all of the time and effort they have dedicated to this thesis research. Their support has allowed me to complete this research and achieve my goal of receiving a Master's degree from West Virginia University. I would also like to thank the rest of the staff in the Department of Forensic and Investigative Science for instilling in me the knowledge and skills necessary to carry out this research. I could not have asked for a better group of advisors and professors. Thank you.

TABLE OF CONTENTS

LIST OF EQUATIONS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Human hair is a common type of physical evidence recovered at the scene of a crime or zones of mass disasters. It is traditionally subjected to light microscopy and nuclear DNA (nDNA) analysis. nDNA analysis is considered the most discriminating method, and can stand alone as a method for differentiation and identification of hair samples, given that the hair sample contains the root, and are therefore an un-degraded sample [1]. The most commonly encountered hairs, however, are degraded samples. For degraded samples, microscopical and mitochondrial DNA (mtDNA) analyses are the most commonly used methods by hair examiners. However, these two analyses independently offer lower levels of discrimination than nDNA, as neither have the potential for individual identification in an open set population [2].

In their report entitled *Strengthening Forensic Science in the United States: A Path Forward*, the National Research Council of the National Academy of Sciences (NAS) stated that though microscopical hair analysis is a technique generally accepted in the scientific community, linking results of this analysis with a particular defendant is highly unreliable. In cases, where it seems that there is a morphological match, mtDNA analysis must be used to confirm in the absence of nuclear DNA. However, no studies have been performed to specifically quantify the reliability of their joint use and the high cost and time associated with mtDNA analysis has deterred many labs from using this method of analysis [3].

The NAS report highlighted the *need to find a more objective method for hair examination that will add value to standard microscopical analysis, when nDNA and mtDNA analysis cannot be performed.* The recent admission of decades of flawed hair analysis by the Federal Bureau of Investigation only supports the aforementioned need [4]. The goal of this study is to develop an objective method to evaluate the ratio of the intra-variability of an individual's head hair samples to the inter-variability of individuals in the population studied, through the use of image analysis. To develop the method, different factors are evaluated to determine which combination of factors yields a statistically significant higher inter-variability when compared to intra-variability. These factors include the number of hairs examined, area of the hair examined, microscope system used, magnification used, focus method used, and normalization technique used. To evaluate these factors, a texture-based statistical method of examination, known as gray-level co-occurrence matrix (GLCM), is used to characterize the texture of each hair sample image. It was hypothesized that only a certain combination of the different factors demonstrates a higher inter-variability than intra-variability and supports a suggested protocol for image analysis of hair samples.

2. LITERATURE REVIEW

2.1. Human Hair

According to Bisbing, hair is defined as a fibrous outgrowth, from the skin of mammals, composed of keratin proteins that interconnect to form stable fibrils. Adjacent keratin chains are linked together by disulfide bonds, making keratin very resistant to biological and chemical degradation [5].

2.1.1. Structure of Hair

The structure of hair can be divided into three anatomical regions, and three structures within those regions. The three anatomical regions are the root, shaft, and distal tip (see Figure 1). The root is the follicular structure at the proximal end of a hair, from where the hair grows. It is also the most DNA-rich region of the hair. The shaft is the mid-section of the hair and is the most commonly compared region of the hair. The distal tip is located at the end of the hair shaft. If the hair is sufficiently un-degraded, then chemical treatments and estimate time since last cutting can be determined [6]. The three hair structures found within these regions are the cuticle, cortex, and medulla (see Figure 2).

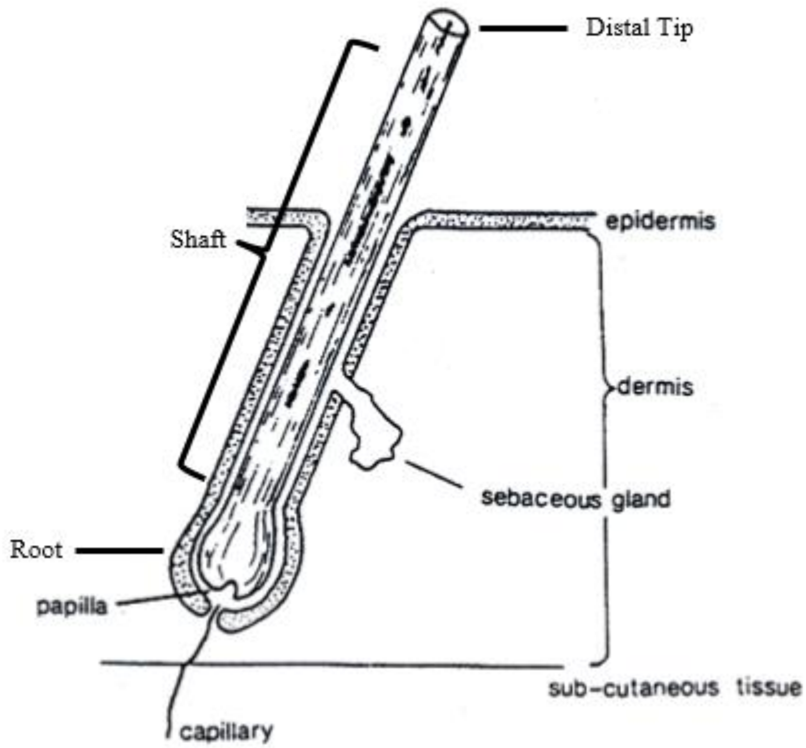

Figure 1: *Anatomical regions of the hair displaying the three main regions: root, shaft, and distal tip [7].*

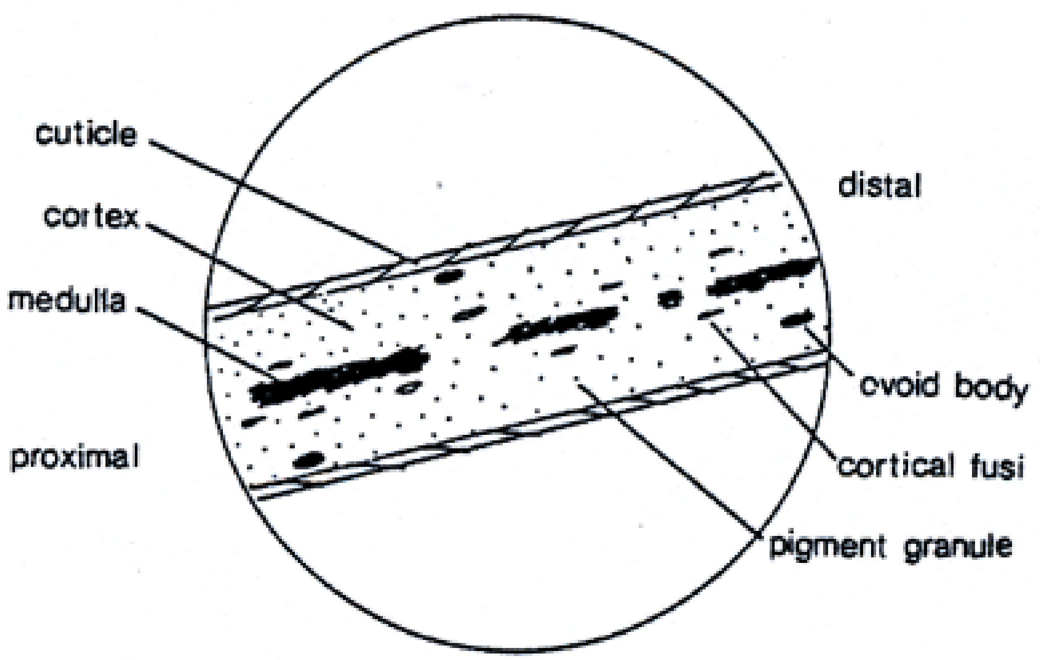

Figure 2: *Basic structure of human hair displaying the three main structures: cuticle, cortex, and medulla* [7].

- Cuticle

The cuticle is the thin, translucent layer that surrounds the shaft of the hair. The cuticle is generally four to ten layers thick, consisting of overlapping, non-nucleated, pigment-free cells that form scales (see Figure 3).

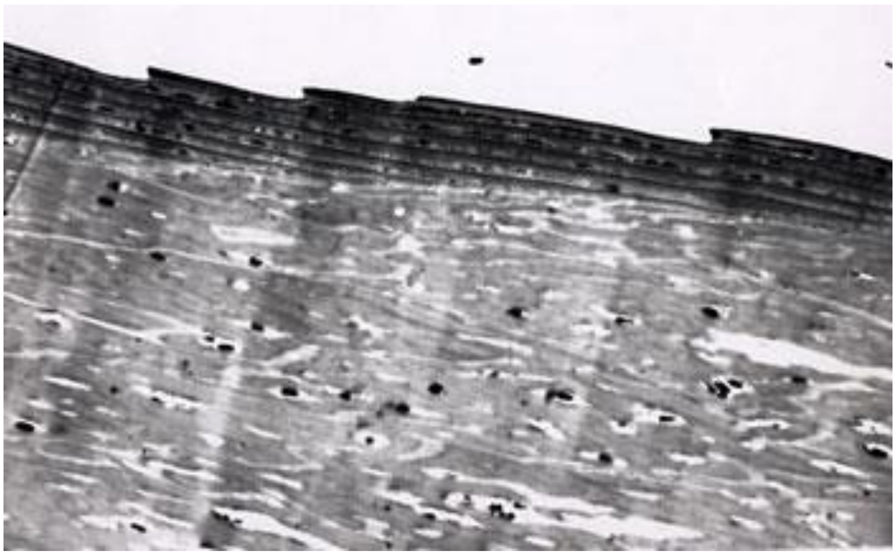

Figure 3: *Transmission electron photomicrograph of cuticular scales* [7].

The cuticle has two margins: the inner cuticular margin and the outer cuticular margin. The inner cuticular margin lines the cortex of the hair. Upon microscopical examination, it can be described as smooth or cracked (see Figure 4). The outer cuticular margin can also be described as cracked, ragged, serrated, or flattened [5].

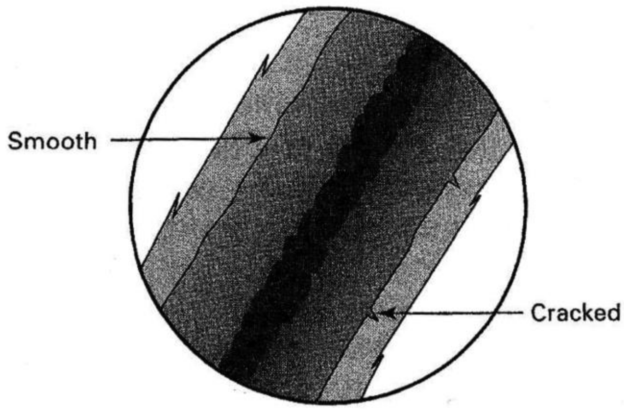

Figure 4: *Inner cuticular margin* [5].

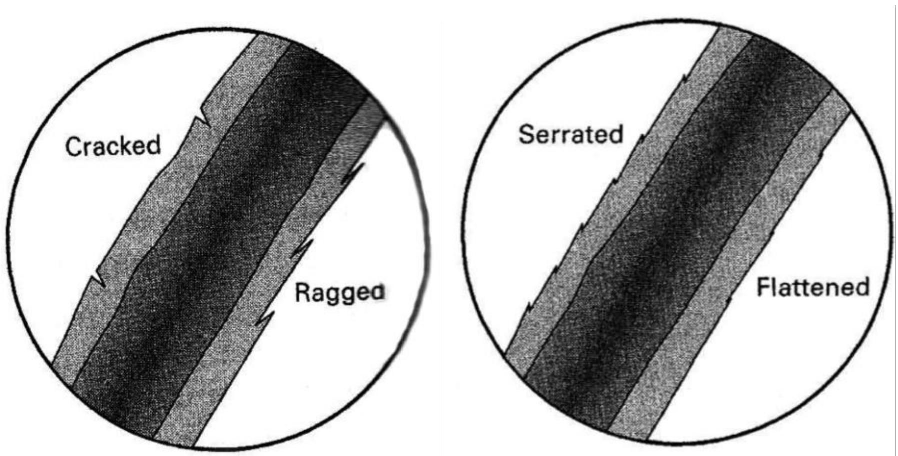

Figure 5: *Outer cuticular margins* [5].

- Cortex

The cortex contributes to the main bulk of the human hair shaft, and is composed of closely packed, keratinized filaments, and cortical fusi. The most distinctive feature of this structure is hair color. It is primarily derived from the kind and amount of pigment present. The size, shape, distribution, and density of pigment granules will differ from individual to individual [5]. For example, the distributions can be described as clear, granular, or clumped (see Figure 6).

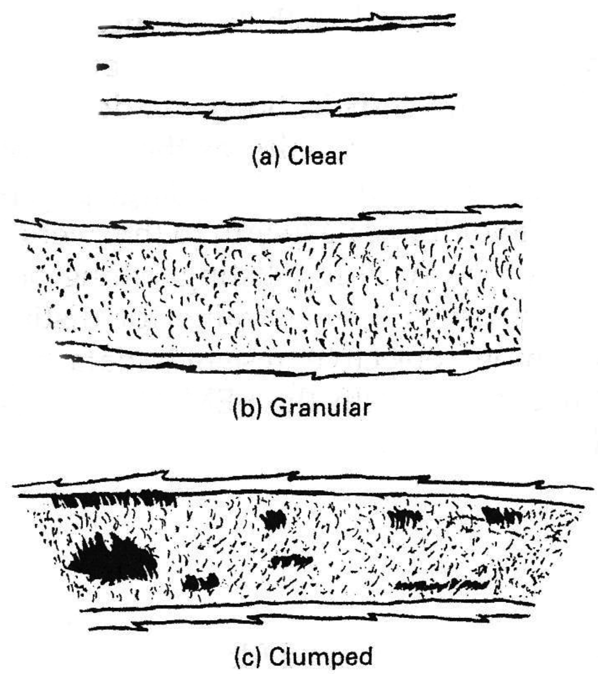

Figure 6: *Pigment distribution in the cortex of the human hair can be described as (a) clear, (b) granular, or (c) clumped* [5].

- Medulla

The medulla is the core of the hair that runs through the center of the cortex. It is comprised of air vacuoles and cells, which leads it to appear dark under transmitted light. The width and general form of the medulla varies from individual to individual, and even between and within hairs of a given individual [5]. Different hair examiners will use different terminology to describe the medulla, but the basic descriptions are fragmented, discontinuous, or continuous (see Figure 7) [8].

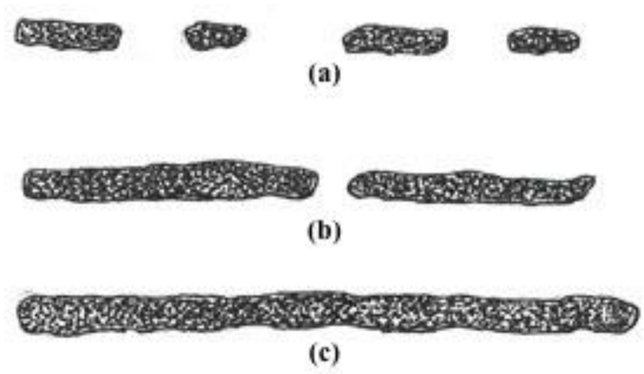

Figure 7: *Three basic medullary types: (a) fragmentary or trace, (b) discontinuous or broken, or (c) continuous* [7].

2.1.2. Phases of Hair Growth

There are three phases of mammalian hair follicle growth. In the anagen phase, the hair is actively growing; the catagen phase is the transitional period between the other two phases; and in the telogen phase, the follicle is dormant [5].

- Anagen Hair Follicle

In the anagen phase, mitotically active cells around the dermal papilla of the follicle grow upward to form the medulla, cortex, cuticle, and root sheath (see Figure 8). These actively growing hairs remain in this phase for several years. Approximately 80% of all follicles will be in the anagen phase. The cells and resulting sheath of this phase are DNA-rich in comparison to the other sections of the hair, making anagen hairs ideal for nDNA analysis [5].

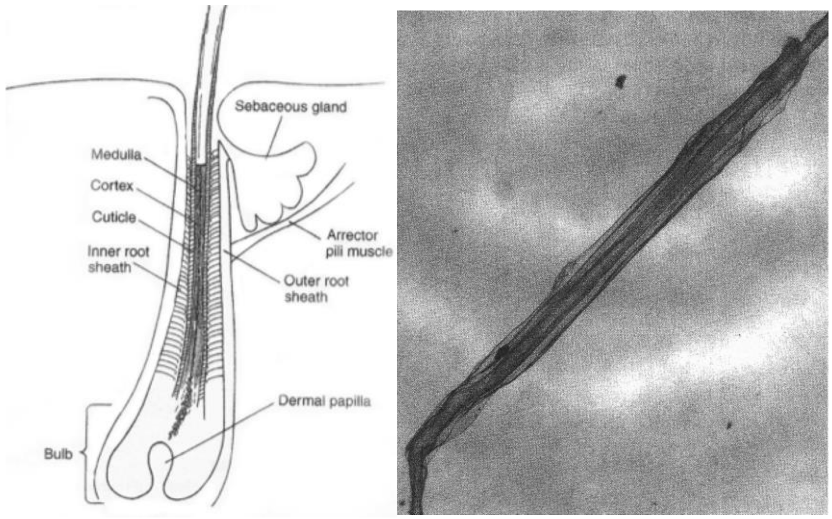

Figure 8: *Anagen hair follicle* [5].

- Catagen Hair Follicle

After a period of growth, the hair stops growing and initiates the catagen or transitional phase, which lasts several weeks. Less than 1% of follicles are in the catagen phase. During this phase, the melanocytes in the follicle contract and stop producing and distributing pigment granules. The root and root sheath shrink and the base of the hair rounds and becomes surrounded by a brush-like capsule called the club (see Figure 9) [5].

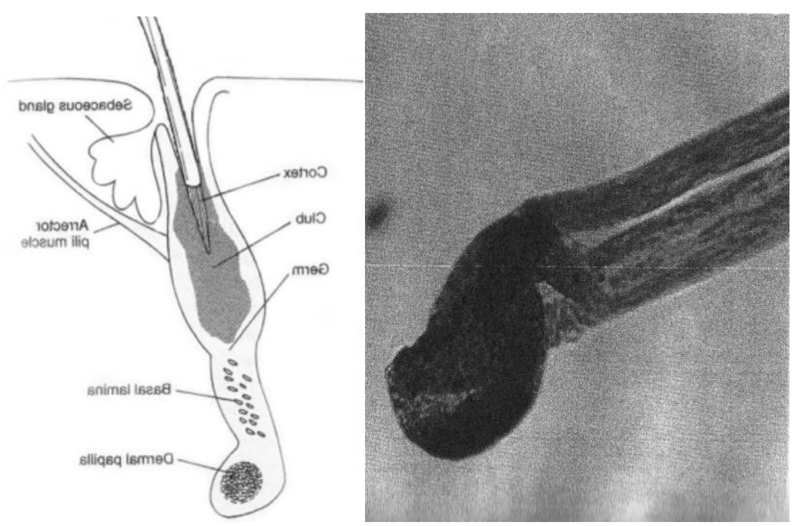

Figure 9: *Catagen hair follicle* [5].

- Telogen Hair Follicle

At the final stage of the growth, a human hair will enter the telogen phase, where the follicles are at the mature and stable stage and the hair is fully developed (see Figure 10). Approximately 20% of follicles are in this phase. A hair in this phase will either be released by mechanical means, such as brushing, or it may be forced from the skin by an emerging hair. Approximately 90-95% of shed hairs are telogen phase hairs. On a scalp containing approximately 100,000 follicles, at least 100 scalp hairs per day will be shed [5]. Therefore, a majority of scalp hairs collected at crime scenes will be telogen phase hairs. Telogen hairs are typically not good candidates for nDNA analysis because of the lack of cellular material, such as the sheath, due to degradation [6].

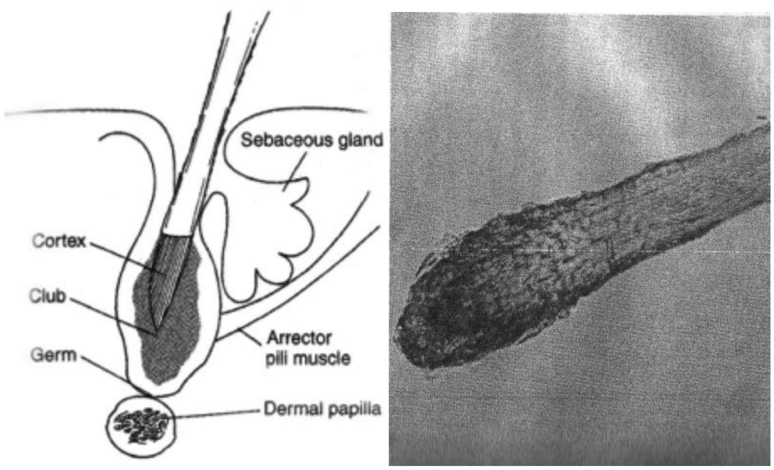

Figure 10: *Telogen hair follicle* [5].

2.1.3. Other Characteristics of Hair

It is generally accepted that color and microscopically observable contributing pigment components are the features most relied upon by forensic hair experts, with color being the most critical comparative characteristic available to the examiner. The color of hair depends on pigmentation, surface transparency, and reflectivity [5]. Therefore, all of the components listed in Table 1 need to be observed and recorded when examining hair, however, different examiners may use different terminology to define color (Table 2).

Table 1: *Color of Hair* [5]

Hue
colorless, blond, golden brown, red, auburn-brown, brown, gray-brown, black
Pigment Density
absent, light, medium, heavy, opaque
Pigment Distribution
uniform, peripheral, one-sided, random, central, gapping
Pigment Aggregation
streaked, clumped, round, oval
Pigment Shape
round, oblong, other
Pigment Size
fine, coarse, mixed
Pigment Color
red, brown, black, mixed

Table 2: *Classification of Hair Color* [9]

Trotter (1939)	Pure black, brown black, dark brown, reddish brown, dark blond, light blond, ash blond, red, albino
Gaudette and Keeping (1974)	Grey, yellow, yellow-brown, red, brown, black
Bisbing (1982)	White, red, auburn, blond, light brown, brown, dark brown, grey brown, grey, black
Robertson (1982)	Colourless/translucent, yellow-brown, yellow-red, reddish brown, light brown, mid brown, dark brown, greyish brown, black
McCrone (1982)	Grey, blond, red, brown, black
Strauss (1983)	(1) Colour Grey, blond, red, light brown, brown, dark brown, black (2) Variation Constant, slight, wide
Harding and Rogers (1984)	(1) Colour White, straw, mid tan, dark tan, yellow brown, red brown, brown, dark brown, black brown, black (2) Intensity In five categories: + to ++++
Lee and De Forest (1984)	(1) Colour Colourless, blond, rust, red, light brown, brown, dark brown, black Chemical treatment (2) Distribution Uniform along shaft Varies along shaft

In addition to color and pigmentation, hair shape and form should always be recorded. Hair shape can indicate body and racial origin, but has a limited discriminating power for single hair samples [5]. Table 3 represents different terminology used by hair examiner experts to describe hair shape and form.

Table 3: *Classification of General Form* [9]

Bisbing (1982)	McCrone (1982)	Strauss (1983)	Harding and Rogers (1984)	Lee and De Forest (1984)	Robertson and Aitken (1986)
Straight	Straight	Straight	Straight	Straight	Straight
Curved	Wavy	Arched	Curved	Arched	Wavy
Wavy	Curly	Curly	Curly	Curly	Curly
Curly	Kinky		Kinky		Peppercorn
Kinky			Twisted		
Undulating					
Sinuous					

In addition to hair form, shaft diameter, pigment granule density and distribution, and cross-sectional shape can be used to indicate racial origin. The typical results for the observation of these characteristics for Caucasian, Negroid, and Mongoloid racial groups are outlined in Table 4. Cross-sectional shape is one of the more relied upon methods of racial classification, where Caucasian cross-sections are typically oval in shape, Negroid cross-sections are typically flat, and Mongoloid cross-sections are typically round [5].

Table 4: *Racial origin* [8]

Caucasian

(a) Shaft diameter moderate with minimal variation (mean diameter for human head hairs is 80 µm).

(b) Pigment granules sparse to moderately dense with fairly even distribution.

(c) Oval cross-sectional shape.

Negroid

(a) Shaft diameter moderate to fine, with considerable variation.

(b) Pigment granules densely distributed (hair shaft may be opaque) and arranged in prominent clumps.

(c) Shaft with prominent twist and curl.

(d) Flattened cross-sectional shape.

Mongoloid

(a) Shaft diameter coarse and usually with little or no variation.

(b) Pigment granules densely distributed and often arranged in large patchy clumps or streaks.

(c) Prominent medulla (broad and continuous).

(d) Cuticle thick.

(e) Round cross-sectional shape.

Disease can cause morphological changes in hair, which can also assist in human hair examination and comparison. These abnormalities are not common, but should always be noted when encountered [5]. Figure 11 outlines the morphological appearance of hairs affected by the most common types of diseases encountered in hair samples.

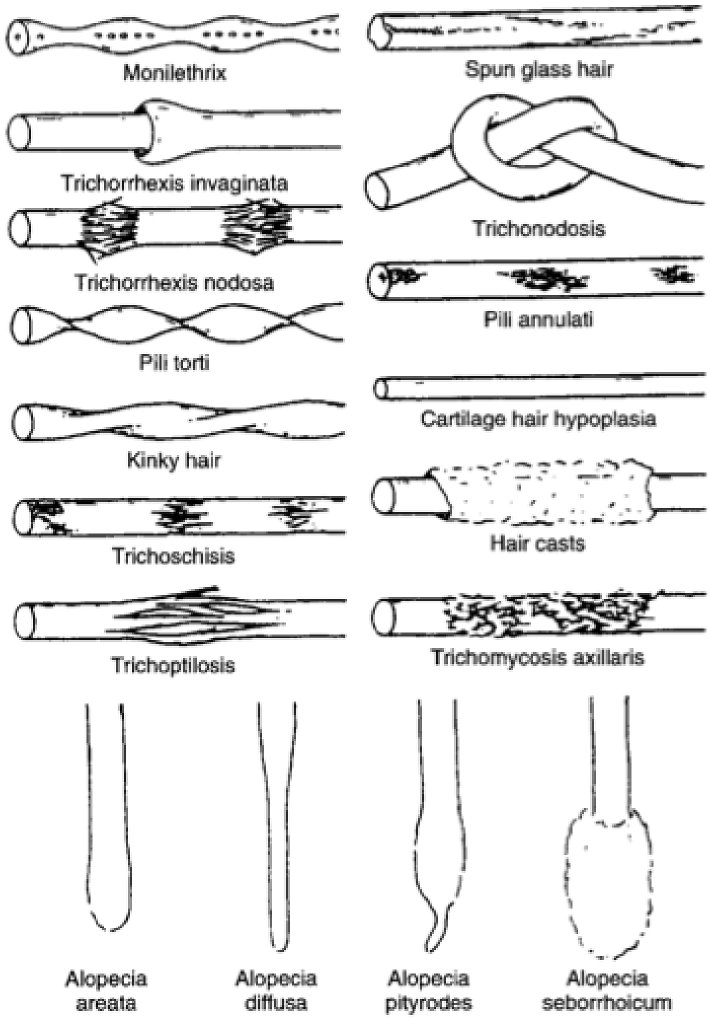

Figure 11: *Schematic diagram of morphological appearance of human head hair afflicted by certain disease conditions* [9].

2.1.4. Traditional Methods of Human Hair Examinations

There are four traditional methods of hair examination. The methods should be performed from general to particular, and from non-destructive to destructive. Therefore, the methods must begin with macroscopical examination, then microscopical examination, and end with nDNA or mtDNA analyses.

- Macroscopical Examinations

Macroscopical examination includes the determination of the color, shape, length and thickness of the hair. This type of examination is typically performed using the naked eye or a stereomicroscope. Root assessment can also be conducted using low power microscopy. Identification of the sample as a human hair, as opposed to an animal hair, should also be determined [6].

- Microscopical Examinations

Microscopical examination includes bright field examination of the color, pigment density and distribution, medulla presence and shape, and treatments and anomalies. Thickness, state of root and tips are also inspected. Medullar index and cross-sectional shape should also be observed [6].

- Nuclear DNA Analysis

Nuclear DNA analysis is the most objective and individualizing method in forensic hair examination. However, DNA must be extracted from the nucleated cells of sheath material or actively growing root cells that are not typically present in the telogen phase hairs, the most commonly encountered hairs in forensic casework [6].

- Mitochondrial DNA Analysis

The last traditional method is mitochondrial DNA analysis. Mitochondrial DNA can be more readily extracted from the shaft of the hair or degraded samples than nuclear DNA. Melton et al. [10] demonstrated a high rate of success for obtaining mtDNA profiles from 691 hairs encountered in casework. According to Melton and Nelson [11], the goals of mtDNA analysis are a) to protect the integrity of evidence by preventing contamination at any stage of testing, and b) to collect the maximum available amount of mtDNA data inherent to any sample for the purpose of obtaining the fullest mitochondrial

DNA profile. Mitochondrial DNA, however, is not as selective as nDNA, due to maternal inheritance. Furthermore, it is not a common practice in forensic laboratories due to the time and expense associated with the method [6].

2.2. Image Analysis

Images are spatial data and can be indexed by two spatial coordinates. A camera senses brightness, and that brightness is transformed to a signal which is fed to the analog-to-digital converter and stored in a computer, referenced to the coordinates, x,y, in the image. An image can be thought of as a matrix of points, where a gray scale image has a value at each point that is proportional to the brightness of the corresponding point. These points are known as picture elements or pixels [12].

Image processing encompasses a wide range of methods, from acquisition to interpretation. Image processing can be used for improvement of the appearance of an image, preparation of images for measurement of features and structures, isolation of objects and structures to measure their size, shape, color, and position, correction of defects and overcoming limitations, enhancement, and interpretation of measurements of structures. Image analysis can also be used for application of statistical-based or other methods to support classification (e.g. co-occurrence matrix) and/or human identification-based studies, namely the capability to identify an individual based on information provided by a human head hair sample [12].

2.2.1. Previous Studies

Previous studies have been published on the classification and identification of hair samples using image analysis. Verma *et al.* [14] developed the Hair Morphological Analysis Prototype (Hair-MAP), a prototype automated system for forensic hair comparison and analysis. They used blonde hair samples and factors such as texture, color, shaft diameter, and medullar index. To determine the accuracy of this prototype, they built a confusion matrix for correct hair matches, and determined that their prototype had an 83% hair match accuracy.

Bednarek [15] attempted to establish objective criteria for morphological examinations of hairs using image analysis. Using digital images, the RGB color model, and the Lucia 4.51 image analysis software, he determined unique color coordinates for 50 blond and 50 brown hairs, which allowed him to correctly identify 91 of the 100 hairs. He performed traditional microscopical analysis defined by Ogle and Fox in *Atlas of Human Hair Microscopic Characteristics* on the same 100 hairs [16], but correctly identified only 74 of the 100 hairs. He concluded that his results give merit to the development and use of image analysis and color models for the comparison of human hairs.

Vaughn *et al.* [17] wanted to evaluate and compare digital image and reflective spectroscopy techniques for measuring hair color in the CIE L*a*b* color model. They used 134 Caucasian individuals, of different hair color, and determined the L*a*b* values for all samples using a V++ software package. They discovered that the L*a*b* values were significantly overestimated in digital images, and that by using digital images, individuals were classified into the correct discriminant analysis clusters only 85.8% of the time with two clusters. This percentage decreased with the increase in the number of clusters. They concluded that though it is more convenient and may be the only evidence for the sample available, digital images using the L*a*b* color model yielded lower percentages of correctly classified hairs than L*a*b* values determined using reflective spectroscopy, for any number of clusters.

Brooks *et al.* [18] reported an objective numerical measure of color and pigmentation to complement microscopical observations using auto-montaged images of 20 Caucasian, brown-haired individuals. The techniques were based on high quality digital images, and using the pixels inherent in the images to obtain numerical values for the features of color and pigmentation. For color, they compared three standard, internationally recognized color models: Red-Green-Blue (RGB) color model, CIE XYZ

Tristimulus color model, and the CIE L*a*b* color model. Using canonical discriminant analysis of the mean color values, the RGB color model yielded the lowest percentage of correctly classified hairs, while the CIE XYZ Tristimulus yielded the highest. The pigment-based pattern analysis was able to separate light and dark-brown haired individuals. Five hairs from one individual was compared to five hairs each from nine other individuals and this resulted in an average of 74.9% probability that a hair from this person would be matched with another from the same person.

Though most previous studies have used hair color as their primary variable, other studies have taken a different approach toward objectively measuring hair using image analysis. Sato [19] gathered numerical data on hair form from Japanese subjects. Hairs were measured for length, distance, and area, and evaluated using stepwise linear discriminant analysis. In 11 of 28 comparisons, 30 hairs from one individual could be completely distinguished from hairs of another, confirming the usefulness of hair form in forensic comparison of hair morphology. In another study, Gurden *et al.* [20] used atomic force microscopy to evaluate hair surface to develop an algorithm for the automatic analysis of AFM images of human hair. Specifically, step height, tilt angle, and density of the cuticle were measured. Their algorithm had a correct classification rate of 86% when 38 hairs samples were examined.

2.2.2. Other Methods of Feature Extraction

In addition to the techniques described by previous work, a technique such as corner extraction can be utilized. Edges are low-level image features, which are basic features that can be extracted automatically from an image with information about spatial relationships that are most obvious to human vision. Curvature is another low level feature that is the rate of change in edge direction. The rate of change characterizes points in a curve. Corners are points at which the edge direction changes rapidly, and straight lines are points where there is little change in edge direction. These points can be useful for shape description and matching [12].

Another approach to image processing is to use high-level image features, such as with region/patch analysis. This allows for the inclusion of scale, where an object can be recognized irrespective of its apparent size. A group or patch of points can be collected to characterize an object in an image, and this allows for recognition where there has been change in viewing arrangement. These arrangements of points can also allow for recognition of image points that have been obscured. By using local neighborhood properties, a description can be obtained that allows for object recognition [12].

Many of the aforementioned feature extraction and description techniques can be used to characterize regions in an image. This characterization can be used for texture analysis. Texture describes patterns with no known analytical description, which can then be used for pattern classification. Texture descriptions can be made through a structural approach, statistical approach, or a combination of the two. Structural approach is the most basic and is done by generating the Fourier transform of an image and then grouping the transform data in some way so as to obtain a set of measurements. The most famous statistical approach is the co-occurrence matrix, which was the first approach to describe, and then classify image texture. The co-occurrence matrix contains elements that are counts of the number of pixel pairs for specific brightness levels, when separated by some distance and at some relative inclination. This statistical approach was selected for this study, because of its popularity and record of good performance [12].

3. EXPERIMENTAL SETUP

The experimental setup for this study can be generally divided into three sections: subjects and samples, hardware and sample-capture devices, and software packages.

3.1. Subjects and Samples

All samples used in this research were collected in a previous study. Using tweezers, at least ten head hair samples each were collected from 120 individuals of varying gender, race, age, and hair color. Twenty of those individuals represented six maternal groups (mother and children), for the purpose of evaluating situations in which mitochondrial DNA analysis would fail to discriminate members of a particular maternal group. Mitochondrial DNA analyses may be the object of a subsequent study using the same sample set. The assignment of the groups can be seen in Table 5. Ten hairs were randomly selected for each individual for imaging.

Table 5: *Maternal Group Assignments*

Group Number	Subject IDs	# of Individuals
1	101-105	5
2	106-108	3
3	109-112	4
4	113-115	3
5	116-117	2
6	118-120	3

Each hair sample was individually mounted on a Fisherbrand Plain Precleaned Microscope Slide using a 1:1 solution of Fisher Scientific Glycerine and distilled water, a non-permanent mounting medium, applied using Fisherbrand 5¾" Disposable Controlled Drop Pasteur Pipets. The slides were covered with Fisherbrand Microscope Cover Glass or Fisherfinest Premium Cover Glass, dependent on the size of the sample. Hair samples that were longer than the length of the slide were carefully cut into sections with the root, middle of hair, and tip sections placed on individual slides. Directionality of each section was marked on the slide.

3.2. Hardware and Sample-Capture Devices

Different image capturing methods were used to represent a variety of instrumentation that may be present in a laboratory. These different methods included the use of four different microscope systems and the use of a 10x or 40x objective lens. The four different microscope systems, as shown in Figure 12, included an Olympus CX31 compound microscope mounted with a Nikon D90 digital camera, a LOMO POLAM L213-M compound microscope mounted with a Nikon D90 digital camera, a Leica DM1000 compound microscope mounted with a Canon EOS Revel XT Digital LSR 350D DS126071 digital camera, and a Leica DM6000B compound microscope mounted with a Leica DFC300 FX camera. The adjustment of the microscopes was performed using Köhler illumination before at the start of each day for each system used, in order to gain optimum contrast, resolution, and consistency by focusing and centering the light path and spreading it evenly over the field of view. Camera settings for the Nikon and Canon digital cameras were ISO 400, aperture f/0, and variable shutter speed dependent on daylight conditions during which the image was captured.

Figure 12: *Hardware and sample-capture devices used (left to right): Olympus CX31 with Nikon D90, LOMO POLAM L213-M with Nikon D90, Leica DM1000 with Canon EOS Revel XT Digital LSR 350D DS126071, and Leica DM6000B with Leica DFC300 FX.*

3.3. Software Packages

- Image Capture

Several different software packages were utilized for image capture, image processing, and statistical analyses. DiyPhotoBits.com Camera Control 5.1 dev software was used for camera control and image capture for the Nikon and Canon digital cameras. Leica DFC camera Software V 7.2.0 was used for camera control and image capture for the Leica DFC300 FX camera. All images were saved as Tag Image File Format (TIFF) images.

- Image Processing

Several software packages were used for image processing. Composite in-focus images were made by inputting a series of the same image captured at different levels of focus into the Syncroscopy Auto-Montage Pro v. 5.03.0061 software. The Pixelmator v. 3.3.1 software was then used to remove the background of the images, by whitening the background using the paint “Brush Tool.” Normalization of image that included converting images to black and white, cropping out the background, and performing an affine transformation, was performed using MATLAB R2014a v. 8.3.0.532 software with the Simulink Student Suite v. 8.3 and Image Processing toolbox. Using MATLAB and the INface toolbox v. 2.0, different normalization techniques were applied to the images in order to highlight different features.

- Statistical Analyses

Statistical measurements were generated by calculating the gray-level co-occurrence matrix for each image generated during normalization using MATLAB. These measurements were analyzed using three different methods available on the XLSTAT 2015 software package. These methods included one-way analysis of variance (ANOVA), Agglomerative Hierarchical Clustering (AHC), and CHi-Square Automatic Interaction Detection (CHAID) reclassification tree.

4. METHODOLOGY

A flow chart summarizing the methodology used in this study can be seen in Figure 13. There are seven steps, each including a series of sub-steps. The first step is the sample preparation of each hair sample. The second step is the capturing of the original images. The third through sixth steps include image processing and the creation of new sets of images. Images created in these steps are then measured in the seventh step, and then statistical analyses are performed on those measurements in the eighth step. The following sections detail the methodology within each step.

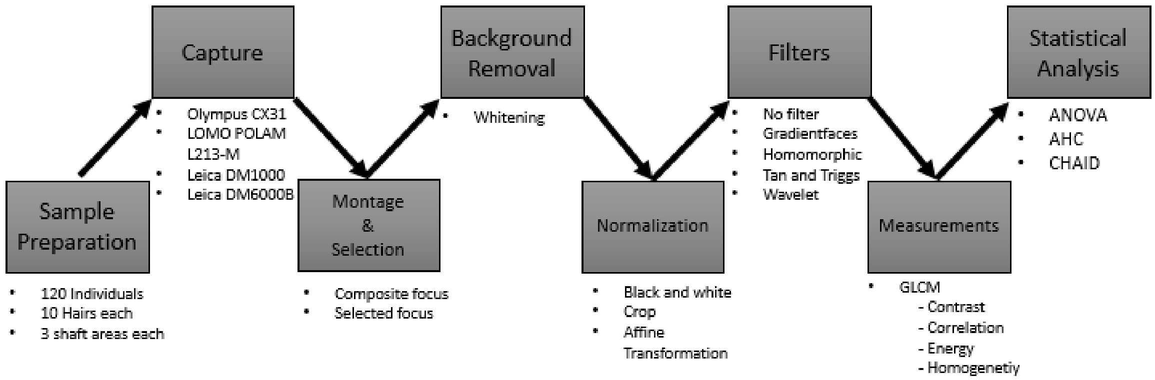

Figure 13: *Flow chart summarizing methodology of the study.*

4.1. Sample Preparation and Image Capture

To initiate the study, two hairs from each of the 120 individuals were mounted using non-permanent mounting medium consisting of a 1:1 mixture of glycerine and water. Under each microscope system, using a 10x objective lens, the hairs were oriented with the root at the lower-left corner of each image and the tip at the upper-right corner. To ensure the best resolution and contrast and evenly illuminated background, the Köhler illumination adjustment was made. Images for five different regions were photomicrographed. These regions included the root, the shaft beginning approximately 2mm away from the start of the root, the shaft in the middle of the length of the hair, the shaft ending approximately 2mm away from the end of the tip, and the tip.

At each region, the focus was set to the point where the center of the hair just comes into focus. At this point, an image was taken. The fine focus knob was turned approximately 2mm towards the direction at which more of the hair comes into focus. At this point an image was taken. This was repeated until no part of the hair was in focus.

A naming scheme was adopted to account for the individual number, hair number, location along the hair shaft, and image number (focus number) at that location. Location numbers were assigned as such: ‘01’ for root, ‘02’ for shaft directly after root, ‘03’ for center of shaft, ‘04’ for shaft directly before tip, and ’05’ for tip. For example, image ‘120_02_05_10.tif’ is associated with individual #120, hair #02, tip (location #05), and image (focus number) #10.

Images were captured for two of the hairs of each of the 120 individuals using each of the microscope systems. These images were montaged and submitted to the biometrics research team at the Lane Department of Computer Science and Electrical Engineering for initial evaluation. Their analysis determined that the root and tip regions did not offer a strong discrimination between intra- and inter-variability of the hairs samples.

Furthermore, their analysis determined that the Olympus CX31 compound microscope yielded better discrimination among the individuals. Based on these conclusions, more images were taken. These images included eight additional hairs for each of the individuals under the 10x objective lens for the Olympus CX31 compound microscope, focusing on the three shaft regions.

Other images included the same 10 hairs for the 120 individuals under the 40x objective lens for the Olympus CX31 compound microscope, again focusing on the three shaft regions. The shaft region images for all microscope systems and objective lenses were subjected to image analysis.

4.2. Image Montage and Selection

The three-dimensionality of the hair samples required ten images to be taken at different focus levels in order to capture every part of the sample in-focus. These images were all montaged into composite in-focus image for each of the shaft regions. This was accomplished using the Auto-Montage Pro software (Syncroscopy, Cambridge, United Kingdom). The procedure used is summarized in Figure 14.

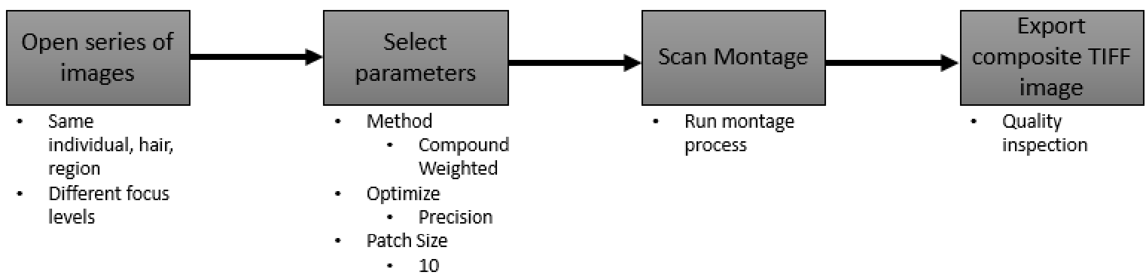

Figure 14: *Flow chart summarizing montaging process.*

For each shaft region, of each hair, the series of images taken at a particular focus level was subject to a montaging process. Within the software, the source images are opened by selecting any one of the images in the series for that region of that hair. The software is able to differentiate each region and hair based on the naming scheme, which are identical except for the final numerical portion.

Once the images are loaded, the ‘Scan Montage’ command is selected and a list of parameters are given for the montaging process. The ‘Method’ parameter includes five options: fixed, blended, weighted, exponentially weighted, and compound weighted. The ‘Compound Weighted’ option was selected because it combines the ‘Weighted’ and ‘Exponentially Weighted’ options to take into account multiple in-focus planes at any one pixel location with a bias towards planes of best focus. The ‘Optimize’ parameter includes two options: Speed and Precision. Precision was selected to avoid fast calculations of best focus that sacrifices clean depth maps for the composite image. The final parameter, ‘Patch Size,’ sets the size of equally-focused regions constructed into a montage image, in the range 1 to 200 [21]. The optimal value was subjectively determined by trial-and-error to be ‘10’. For consistency in method, these selected parameters were applied to all images montaged.

Following the ‘Scan Montage’ command, the composite image was inspected and then exported as a TIFF image. The montaging process was repeated for each region of each hair of each individual for all microscope systems and objective lenses.

Before final preparations for image analysis and after the montaging process, an image was subjectively chosen among the focused images to represent the best in-focus image for each shaft region observed under the 40x objective lens for the Olympus CX31 compound microscope. These images are referred to as the ‘Selected’ images. A representative photomicrograph of selected and montaged images can be found in Figures 15 and 16, respectively.

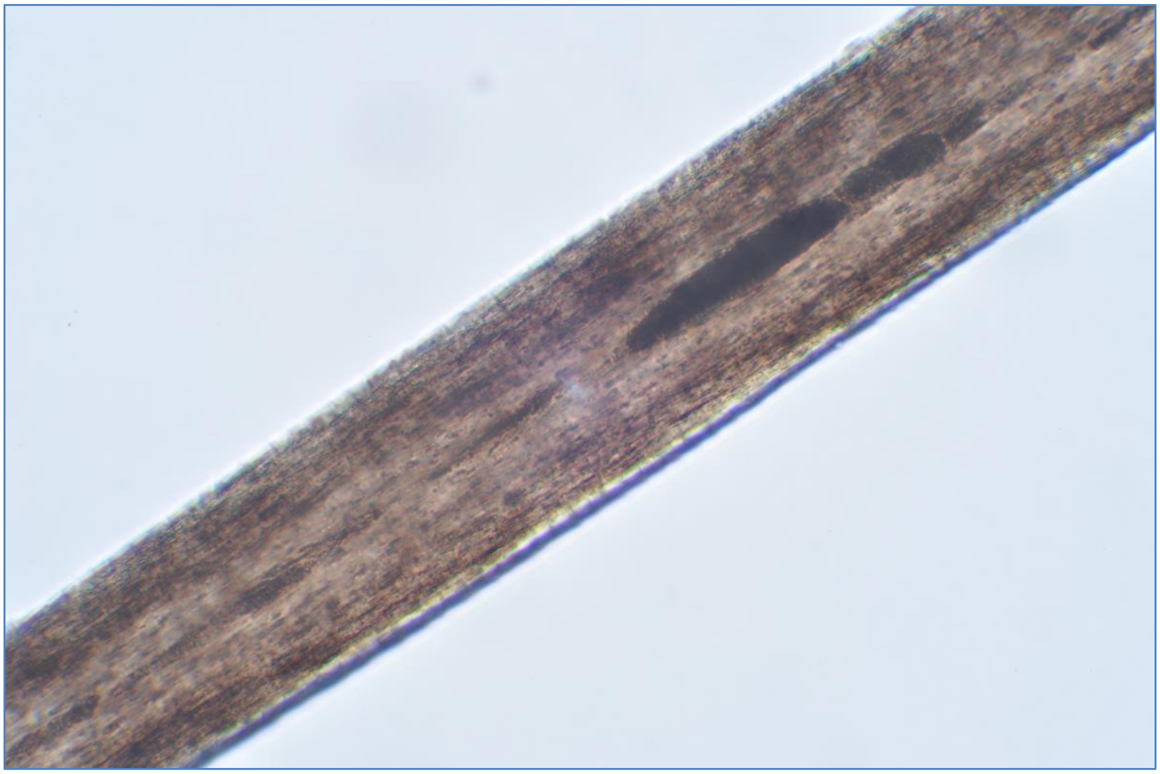

Figure 15: *Representative photomicrograph of best focus selected image. Photomicrograph was taken using Olympus CX31 compound microscope and a 40x objective lens. This hair was shaft #2 of hair #9 of individual #30.*

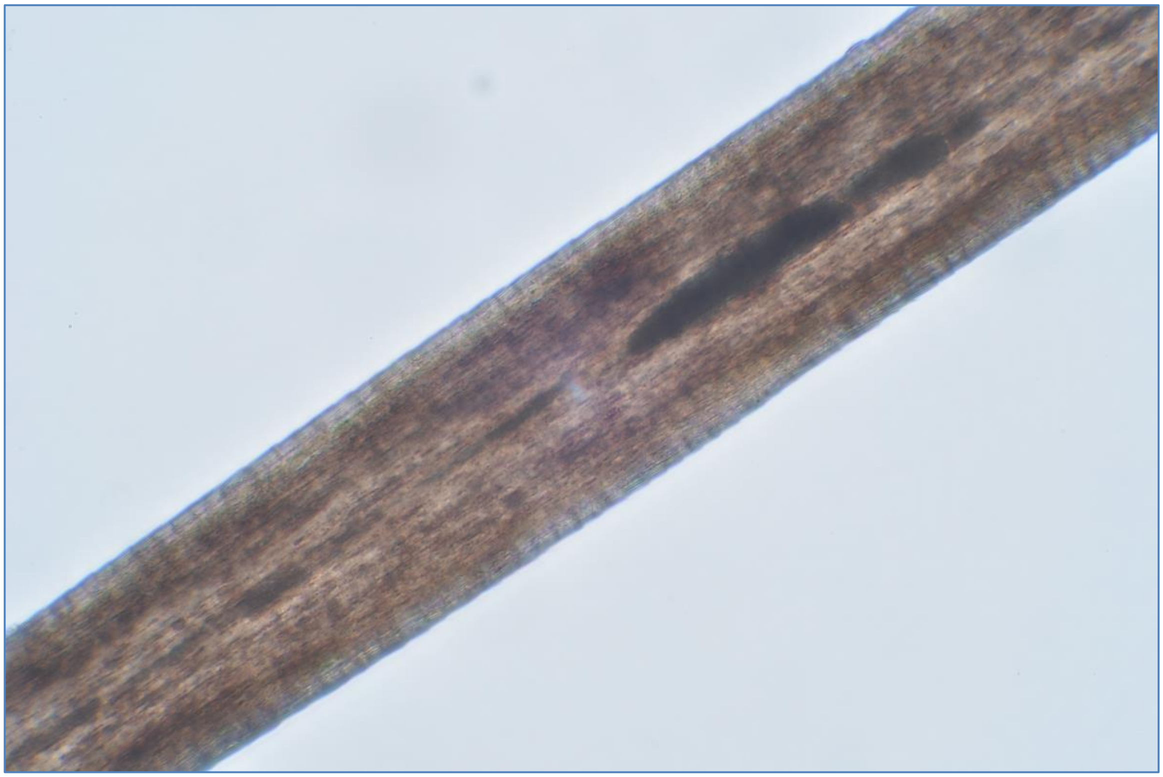

Figure 16: *Representative photomicrograph of montaged image using Auto-Montage Pro software. Photomicrograph was taken using Olympus CX31 compound microscope and a 40x objective lens. This hair was shaft #2 of hair #9 of individual #30.*

4.3. Background Removal

Removal of the background was necessary for normalization to work properly, as foreign particles or air bubbles in the background can interfere. During normalization of the images, it was determined that a threshold could not be found to automatically whiten the background of all images without whitening parts of the hair sample, as well. The best solution was determined to be manually whitening the background using the Pixelmator software (Pixelmator Team, Vilnius, Lithuania). All best-selected images and montaged images were subjected to manual background whitening before normalization (see Section 4.4).

Manual whitening was performed by using the ‘Paint Selection Tool’ to select the background area automatically, on each side of the hair. The ‘Paint Bucket Tool’ was used to apply a white background to 100% of the selected area with 100% opacity. The ‘Brush Tool’ was used to white out the edges of the area selected with the ‘Paint Selection Tool.’ For images, where the ‘Paint Selection Tool’ failed to properly select the background automatically, the ‘Brush Tool’ was used to manually paint over all of the background. These whitened images were saved with the same label in a separate location from the originals, before being subjected to normalization. A representative photomicrograph of an image with the background removed can be found in Figure 17.

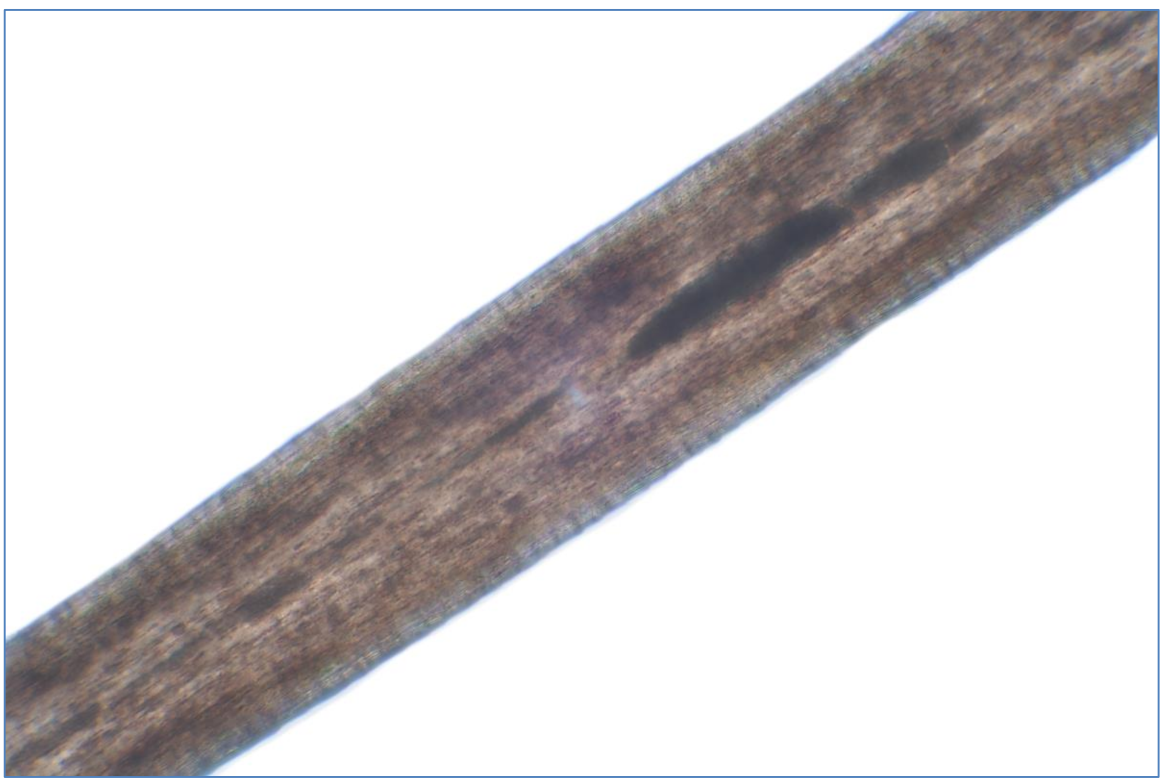

Figure 17: *Representative photomicrograph of image with background removed. This montaged photomicrograph was taken using Olympus CX31 compound microscope and a 40x objective lens. This hair was shaft #2 of hair #9 of individual #30.*

4.4. Image Normalization

Final preparations involved normalizing all images to be processed. The normalization was completed using MATLAB (see Appendix A). The process involved converting the images into gray-scale, converting from gray-scale into black and white, dilating the resulting image to remove stray, isolated pixels, converting the white background into black, superimposing the black background on the gray-scale image, performing an affine rotation, and finally cropping out as much of the background as possible. Rather than simply rotating each image, affine rotation was performed, in order to preserve relationship between points on a single line, and straight lines and planes, while retaining the extra pixels gathered from hairs oriented diagonally in the original image, as opposed to a horizontal orientation. These images were saved with a '_reg1' appended to the end of their labels (e.g. '120_10_01.tif' became '120_10_01_reg1.tif' following normalization). A representative photomicrograph of a normalized image can be found in Figure 18.

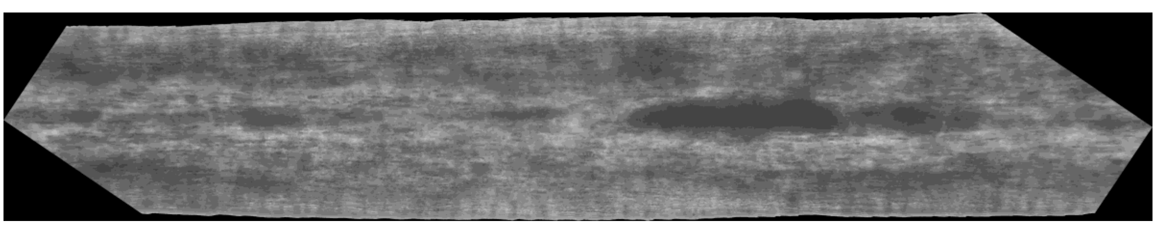

Figure 18: *Representative photomicrograph a normalized image. This montaged photomicrograph was taken using Olympus CX31 compound microscope and a 40x objective lens. This hair was shaft #2 of hair #9 of individual #30.*

4.5. INface Toolbox Techniques

Using MATLAB (MathWorks, Natick, MA, USA) and the Illumination Normalization techniques for robust Face recognition (INface) toolbox v2.0, different techniques were applied to the normalized images. The INface toolbox is a collection of MATLAB function and scripts that was intended to help researchers in the field of facial recognition. It includes 18 different photometric normalization techniques. All 18 techniques were applied to one image and it was determined that only four of those techniques would work with images of hair rather than faces. The techniques that worked included the homomorphic-filtering-based, wavelet-based, Gradientfaces, and Tan and Triggs normalization techniques. These four techniques were applied to all normalized images (see Appendix A).

The Gradientfaces normalization technique computes the orientation of the image gradients in each pixel in the image and uses the computed representation as an illumination invariant version of the input image [22]. The resulting representations were saved with a '_reg4' appended to the end of their labels (e.g. '120_10_01_reg1.tif' became '120_10_01_reg4.tif' following the Gradientfaces normalization technique). A representative photomicrograph of a Gradientfaces normalized image can be found in Figure 19.

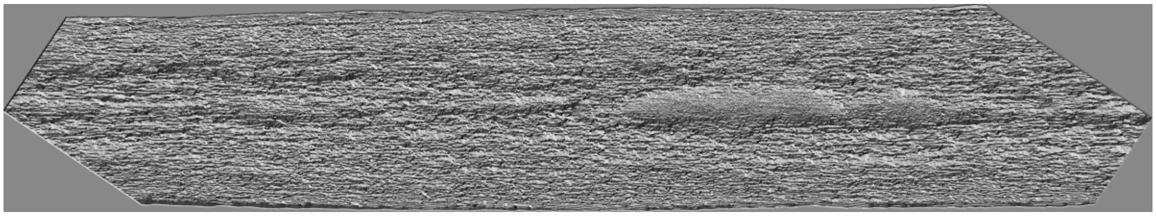

Figure 19: *Representative photomicrograph a Gradientfaces normalized image. This montaged photomicrograph was taken using Olympus CX31 compound microscope and a 40x objective lens. This hair was shaft #2 of hair #9 of individual #30.*

The Homomorphic-filtering-based normalization technique transforms the normalized image into a logarithm and then into a frequency domain. High frequency components are emphasized and low-frequency components are reduced before the image is transformed back into the spatial domain using the inverse Fourier transform and taking the exponential of the result [22]. The resulting images were saved with a '_reg2' appended to the end of their labels (e.g. '120_10_01_reg1.tif' became '120_10_01_reg2.tif' following the Homomorphic-filtering-based normalization technique). A representative photomicrograph of a Homomorphic-filtering-based normalized image can be found in Figure 20.

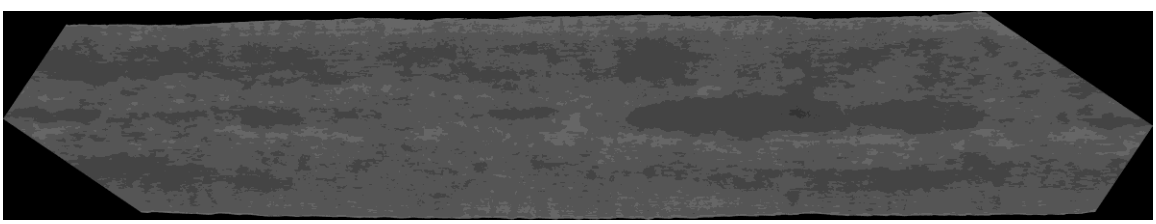

Figure 20: *Representative photomicrograph a Homomorphic-filtered-based normalized image. This montaged photomicrograph was taken using Olympus CX31 compound microscope and a 40x objective lens. This hair was shaft #2 of hair #9 of individual #30.*

The Tan and Triggs normalization technique, normalizes the input image through the use of a processing chain that first applies gamma correction to the image, then subjects the corrected image to difference of Gaussians (DoG) filtering. The final result is produced by using a robust post-processor [22]. The final results were saved with a '_reg5' appended to the end of their labels (e.g. '120_10_01_reg1.tif' became '120_10_01_reg5.tif' following the Tan and Triggs normalization technique). A representative photomicrograph of a Tan and Triggs normalized image can be found in Figure 21.

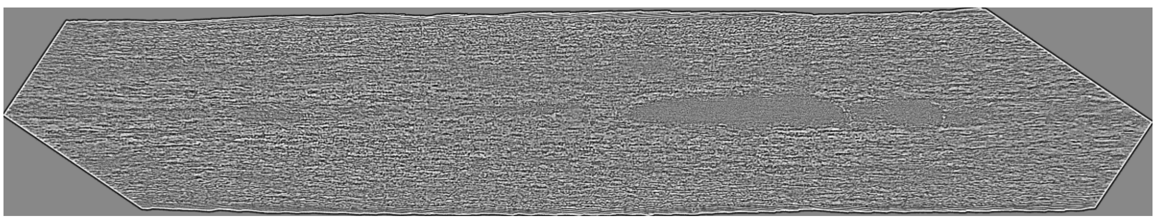

Figure 21: *Representative photomicrograph a Tan and Triggs normalized image. This montaged photomicrograph was taken using Olympus CX31 compound microscope and a 40x objective lens. This hair was shaft #2 of hair #9 of individual #30.*

The final technique, the Wavelet-based normalization technique applies discrete wavelet transform to an image and then processes the obtained sub-bands, which emphasizes the matrices of detailed coefficient and applies histogram equalization to the approximate coefficients of the transform. The image is then reconstructed using the inverse wavelet transform [22]. The resulting images were saved with a '_reg3' appended to the end of their labels (e.g. '120_10_01_reg1.tif' became '120_10_01_reg3.tif' following the Wavelet-based normalization technique.). A representative photomicrograph of a Wavelet-based normalized image can be found in Figure 22.

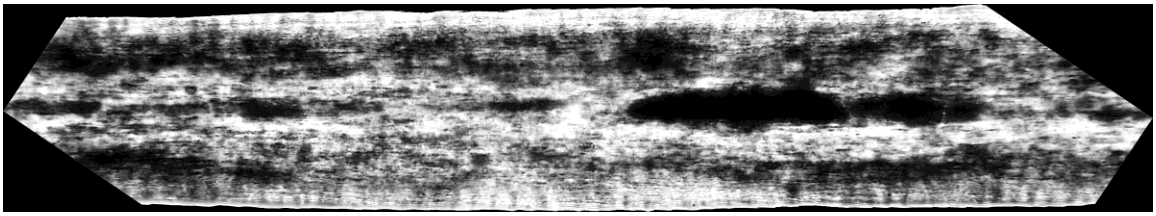

Figure 22: *Representative photomicrograph a Wavelet-based normalized image. This montaged photomicrograph was taken using Olympus CX31 compound microscope and a 40x objective lens. This hair was shaft #2 of hair #9 of individual #30.*

4.6. Gray-Level Co-Occurrence Matrix (GLCM)

Next, the gray-level co-occurrence matrix (GLCM) was applied (see Appendix A). This statistical method for examining texture in an image considers the spatial relationship of pixels. It characterizes the texture of an image by calculating how often pairs of pixels with specific values, along with the specified spatial relationship, occur in an image. This creates the gray-level co-occurrence matrix, in which statistical measures can be extracted. These statistical measures include 'Contrast,' 'Correlation,' 'Energy,' and 'Homogeneity.'

'Contrast', or "sum of squares variance," measures the pixel intensity contrast between a pixel and its neighbor over the entire image using the equation:

$$\sum_{i=1}^{K}\sum_{j=1}^{K}(i-j)^2 p_{ij}$$

Equation 1: *Contrast Formula*

where if i and j are equal, the cell is on the diagonal and (i-j) = 0 and the values represent pixels entirely similar to their neighbor thereby giving it a weight of 0. If i and j differ by

1, then there is a small contrast and the weight is 1. If i and j differ by 2, contrast is increasing and the weight is 4. As (i-j) increases, the weight will increase exponentially.

‘Correlation’ measures the joint probability occurrence of the specified pixel pairs using the equation:

$$\sum_{i=1}^{K}\sum_{j=1}^{K}\frac{(i-\mu_r)(j-\mu_c)p_{ij}}{\sigma_r\sigma_c}$$

$$\sigma_r \neq 0; \sigma_c \neq 0$$

Equation 2: *Correlation Formula*

where the range of values is 1 to -1 and corresponds to the perfect positive or negative correlations. This measure is not defined if either standard deviation is zero.

‘Energy’ provides the measure of uniformity, or sum of squared elements, using the equation:

$$\sum_{i=1}^{K}\sum_{j=1}^{K} p_{ij}^2$$

Equation 3: *Energy Formula*

where uniformity is 1 for a constant image i.

Finally, ‘homogeneity’ measures the closeness of the distribution of elements in the image to the diagonal, using the equation:

$$\sum_{i=1}^{K}\sum_{j=1}^{K}\frac{p_{ij}}{1+|i-j|}$$

Equation 4: *Homogeneity Formula*

where weights are decreasing exponentially from the diagonal as values are weighted by the inverse of the contrast weight. The range of values is [0,1], with the maximum being achieved when the image is a diagonal matrix.

The statistical measures of the GLCM were calculated for all normalized images [23].

4.7. Statistical Analyses

4.7.1. One-Way Analysis of Variance (ANOVA)

The first statistical test run was a one-way analysis of variance (ANOVA) using XLSTAT 2015. ANOVA analyzes the differences in means among individuals in the population of 120 and among the hairs of each individual. Mathematically, ANOVA can be written as:

$$x_{ij} = \mu_i + \epsilon_{ij}$$

Equation 5: *General One-Way ANOVA Formula*

where x is the individual data points (i and j are the individual and hair number, respectively), ϵ is the unexplained variation, and the parameters of the model (μ) are the population means of each individual. Four basic assumptions are made when using

ANOVA: the expected values of the errors are zero, the variances of all errors are equal to each other, the errors are independent, and that they are normally distributed.

ANOVA is used to get the probability of obtaining data assuming a null hypothesis. In this research, the null hypothesis is that the means for each individual are equal. The alternative hypothesis is that at least one population mean is different from the rest. To determine which hypothesis is plausible, the F-value (test statistic) and p-value (probability that measures the plausibility of the null hypothesis) are calculated. If the F-value is less than the F critical value, then the null hypothesis is rejected. If the F-value is greater, then the null hypothesis cannot be rejected. A significant p-value ($p < (\alpha = 0.05)$) suggests that at least one individual mean is significantly different from the others.

To calculate the F-value, the variation, also called the sum of squares, for between-individual and within-individual must be calculated. The between group variation is calculated by comparing the mean of each individual by the overall mean of the data:

$$\text{Between SS} = n_1(x_1\text{-}x)^2 + n_2(x_2\text{-}x)^2 + n_3(x_3\text{-}x)^2 + \ldots$$

Equation 6: *Between-Individual Variation Formula*

where x_i is the individual mean, x is the population mean, and n_i is the sample size. To estimate the mean variation between individuals, this calculation can be divided by the number of degrees of freedom (sample size – 1, or n-1):

$$\text{Estimate of mean variation between individuals} = \frac{\text{Between SS}}{(n-1)}$$

Equation 7: *Mean Variation Between-Individuals Formula*

The variation within individuals is the variation of each hair from the group mean of the individual:

$$SS_R = s^2_{individual1}\,(n_{individual1} - 1) + s^2_{individual2}\,(n_{individual2} - 1) + s^2_{individual3}\,(n_{individual3} - 1) + \ldots$$

Equation 8: *Within-Individual Variation Formula*

where s^2 is the variance of the corresponding individual, and multiplying this by the degrees of freedom for each individual to get the variation between hairs of that individual. The F-value is finally calculated as:

$$\text{F-value} = \frac{\text{Mean between individuals variance}}{\text{Mean within-group variance}}$$

Equation 9: *F-value Formula*

If the average difference between individuals is similar to that within the hairs of the individuals, the F-value is about 1. As the average difference between individuals becomes greater than that between the hairs of an individual, the F-value becomes larger than 1. For each method of analysis, if the F-value is greater than the F critical value, then the null hypothesis should be rejected [24]. The F critical value is found in the F-Distribution tables using the between-individual and within-individual degrees of freedom [25].

The p-value is the probability of getting that F-value or a greater one. Larger F-values will result in smaller p-values. A p-value less than the selected alpha level of significance, $\alpha = 0.05$, can be reported as a statistically significant difference between individual means. The alpha level is, by definition, the probability of a Type 1 error occurrence, where the null hypothesis is true, but it is rejected. Furthermore, a low p-value means that the differences among means of each individual are very unlikely to have been caused by chance [24]. The p-value is calculated by finding the right-tailed F probability distribution that measures the degree of diversity between data sets:

$$p = P(X > \text{F-value})$$

Equation 10: *p-value Formula*

To determine where the statistically significant differences lie, a multiple comparisons test needs to be run (e.g. Tukey's test) [24]. It was not the objective of this research to determine which individual had hair with a statistically significant difference from the others, but rather which method of image analysis would yield a higher difference or discrimination among the individuals. Therefore, multiple comparisons tests were not run, but cluster and classification trees were utilized to evaluate the population of individuals as a whole.

4.7.2. Agglomerative Hierarchical Clustering (AHC)

To evaluate the clustering mechanism of the population of individuals sampled for each combination of variables, Agglomerative Hierarchical Clustering (AHC) was used. AHC is an iterative classification method that starts by calculating the dissimilarity between the 120 individuals. Two individuals, which when clustered together minimize a given agglomeration criterion, are then clustered together thus creating a class comprising these two individuals. Then the dissimilarity between this class the N-2 (118) other objects is calculated using the agglomeration criterion. The two individuals whose clustering together minimizes the agglomeration criterion are then clustered together. This process continues until all individuals have been clustered. These clustering operations produce a dendrogram that represents a hierarchy of partitions. The agglomeration method used in this research was Ward's method, which aggregates two groups so that within-individual inertia increases as little as possible to keep the clusters homogeneous [26].

The results of this test using XLSTAT 2015 yields a levels bar chart, a dendrogram, and a table that shows the clusters and where individuals have been classified. The table shows the cluster assignments was of interest in this research, as it reveals the number of clusters formed among all hairs in the population. This allows for the observation of the intra- and inter-variation of cluster assignment. Due to the large sample size, the levels bar chart and dendrogram are unreadable, which is a known disadvantage of AHC.

4.7.3. CHi-Square Automatic Interaction Detection (CHAID) Reclassification Tree

The final statistical analysis performed was to compare each combination of variables for classification performance. This was done using classification and regression tree analysis, which is explanatory and predictive methods that identify groups based on rules that explain a phenomenon recorded through qualitative or quantitative dependent variables. In doing so, the most important explanatory variables are identified. The value of a dependent variable for a new observation can then be predicted. The CHi-

Square Automatic Interaction Detection (CHAID) reclassification tree utilizes three steps: splitting, merging, and stopping [27].

The data is first split by starting with the root node that contains all of the individuals, and the best split variable is selected based on the lowest P-value gathered from the results of ANOVA. The split is performed if the P-value is lower than the threshold (0.05). In the case of a quantitative dependent variable, ANOVA is used to find the variable that best explains the variation of the dependent variable Y [27].

Similar categories of that variable are then merged into common sub nodes. This is repeated recursively until the maximum P-value is smaller or equal to the threshold (0.05), or until there are only two remaining categories [27].

For every newly created sub-node, the stop criteria are checked. If none of the criteria are met, the node is treated in the same way as the root node. The stop criteria include a pure node, maximum tree depth, minimum size for a parent-node, and minimum size for a son-node. The pure node is a node that contains only objects of one category or one value of the dependent variable. The maximum tree depth is the point at which the level of the node has reached the user defined maximum tree depth. The minimum size for a parent-node is the point at which the node contains fewer objects than the user defined minimum size for a parent-node. The minimum size for son-node is the point after splitting of this node, that there is at least one sub-node which size is smaller than the user defined minimum size for a son-node [27].

The results of this test using XLSTAT 2015 yields the tree structure, classification tree, information available at each node, and rules used to build the tree. Of particular interest in this research were the “Results by object” table, which computes predictions for each hair and classify or miss-classify them to an individual, and the confusion matrix for the estimation sample. The confusion matrix summarizes the reclassification of the observations and presents the percentage of well classified hairs, which is the ratio of the number of hairs that have been well classified over the total number of observations.

5. RESULTS AND DISCUSSION

5.1. One-Way Analysis of Variance (ANOVA)

The results of the one-way Analysis of Variance (ANOVA) yield estimated variance between individuals and estimated variance between the hairs of each individual. ANOVA was performed for each combination of microscope system, objective lens, focus method, number of hairs per individual, normalization filter applied, hair region, and Gray-Level Co-Occurrence Matrix (GLCM) statistic. The results of ANOVA for each combination of variables can be found in Appendix C.

If the F-value was greater than the F critical value, the null hypothesis, in which the means for each individual in the population are the same, can be rejected. If the p-value is less than the alpha level value of 0.05, then a statistically significant difference between the means can be reported. Of the 420 combination of variables tested, 374 or 89.05% of those yielded an F-value greater than the F critical value and a p-value less than 0.05. Figure 23 and Figure 24 display the F-value and p-value, respectively. There was not a situation in which the F-value would be less than the F critical value while the p-value was greater than the alpha level, and vice versa.

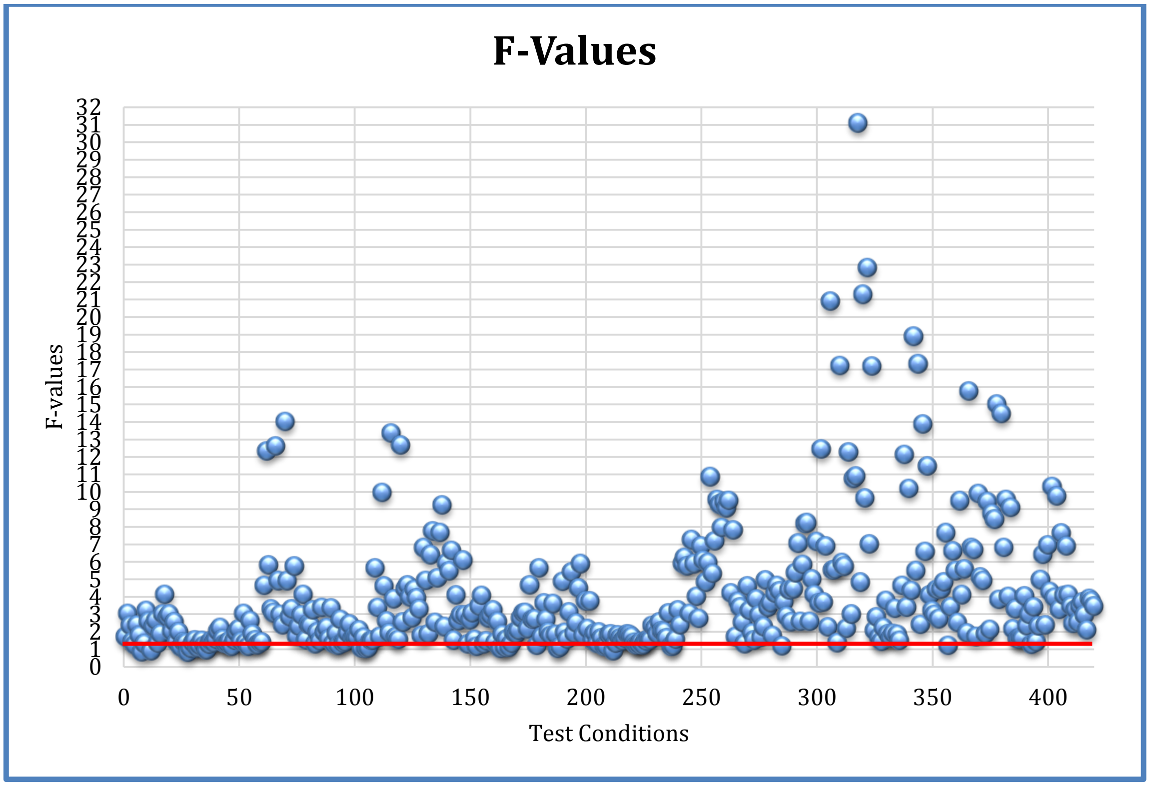

Figure 23: *F- values for all test conditions. All values above F critical value = 1.35259934 (red line) represent test conditions where the null hypothesis is rejected.*

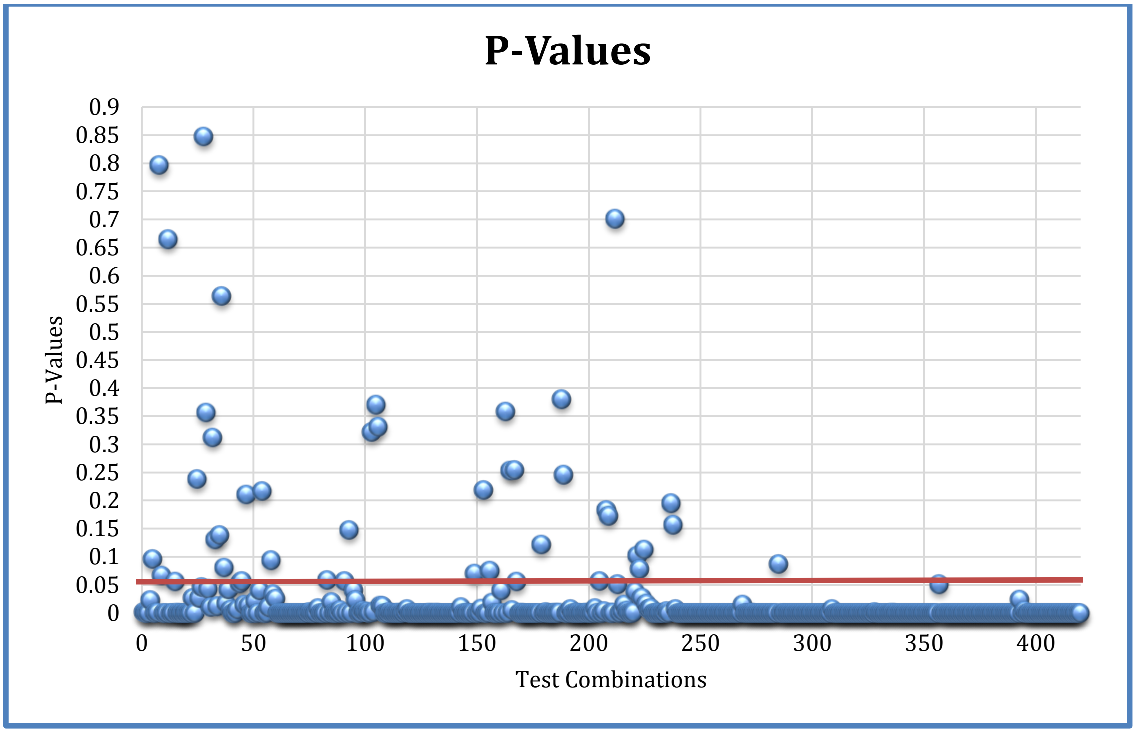

Figure 24: *P-values for all test conditions. All values below α = 0.05 (red line) represent test combinations where there is a statistically significant difference between the means of the individuals.*

The greater the F-value, the greater the average difference between individuals becomes, as compared to that between the hairs of an individual, and the stronger the evidence is for both determining the null hypothesis to be false and rejecting it. As shown in Figure 23, a large portion of the test combinations were at least double the F critical value, meaning that there was greater average between-individual variation than within-individual variation.

The smaller the p-value, the lower the probability of encountering a Type I error, where the null hypothesis is rejected when it is true. As shown in Figure 24, a majority of the test combinations were far smaller than the alpha level, with most approaching a p-value of zero.

5.2. Agglomerative Hierarchical Clustering (AHC)

The results of Agglomerative Hierarchical Clustering (AHC) reveal grouping of the hairs of the individuals. The results of AHC can be found in Appendix D. The details of individual assignment into the classes, or nodes, was not included due to the large sample size and number of test combinations. The number of objects, sum of weight, within-class variance, minimum distance to the centroid, maximum distance to the centroid, and mean distance to the centroid for each test combination are included.

Table 6 displays the number of nodes for each of the test combinations. As shown in the table, the minimum number of classes/nodes found was three, with the majority being as such. The higher the number of classes, the greater the dissimilarity found among all of the hairs.

Table 6: *Number of classes/nodes per test combination*

		Leica 1000	Leica 6000	Lomo	Olympus 10x - 2 Hairs	Olympus 10x - 10 Hairs	Olympus 40x - Montaged	Olympus 40x - Selected	*Average*
No Filter	***Shaft 1***	5	5	4	3	3	3	3	**3.714286**
	Shaft 2	4	5	4	3	4	6	3	**4.142857**
	Shaft 3	3	3	3	3	4	3	4	**3.285714**
Gradientfaces	***Shaft 1***	3	3	3	3	3	5	5	**3.571429**
	Shaft 2	3	3	3	3	3	6	5	**3.714286**
	Shaft 3	3	4	3	3	3	5	5	**3.714286**
Homomorphic	***Shaft 1***	3	3	3	3	3	3	3	**3**
	Shaft 2	4	4	3	3	3	3	3	**3.285714**
	Shaft 3	3	4	4	3	3	3	3	**3.285714**
Tan and	***Shaft 1***	3	4	3	3	3	5	4	**3.571429**
Triggs	***Shaft 2***	4	3	3	3	5	5	4	**3.857143**
	Shaft 3	3	4	4	3	3	4	4	**3.571429**
Wavelet	***Shaft 1***	4	3	5	3	4	4	4	**3.857143**
	Shaft 2	4	3	3	3	4	4	4	**3.571429**
	Shaft 3	7	5	6	3	4	4	5	**4.857143**
	Average	**3.733333**	**3.733333**	**3.6**	**3**	**3.466667**	**4.2**	**3.933333**	

Within-individual variation was seen in every test combination, meaning that at least one individual had hairs assigned to different classes. Table 7 displays the percentage of individuals out of 120 individuals had all hair assigned to the same class. Corrected values were calculated due to the imbalance in number of hairs per test combination and the need to compare all test combinations. Specifically, 45 of the 420 test combinations feature 10 hairs per individual, while the remaining feature two hairs per individual. The values within parentheses are the original percentages, factoring in only two hairs per individual. The values ending with an asterisk, *, are the corrected values. These values are equal to the value in the parentheses divided by 5 to represent the theoretically expected value had there been 10 hairs for that test combination rather than two.

Table 7: Percentage of individuals with all hair clustered in the same node

		Leica 1000	Leica 6000	Lomo	Olympus 10x - 2 Hairs	Olympus 10x - 10 Hairs	Olympus 40x - Montaged	Olympus 40x - Selected	*Average*
No Filter	***Shaft 1***	11.5* (57.5)	10.17* (50.83)	12.17* (60.83)	11* (55)	14.17	28.33	16.67	**14.85857* (40.47571)**
	Shaft 2	14.17* (70.83)	12.67* (63.33)	14.33 * (71.67)	10.83* (54.17)	5	2.5	20.83	**11.48* (41.19)**
	Shaft 3	13* (65)	11.83* (59.17)	11.67* (58.33)	12.5* (62.5)	2.5	15	15	**11.64286* (39.64286)**
Gradientfaces	***Shaft 1***	11.17* (55.83)	12.33* (61.67)	12.5* (62.5)	12.5* (62.5)	10	13.33	22.5	**13.48* (41.19)**
	Shaft 2	11.17* (55.83)	13.33* (66.67)	15.17* (75.83)	13.67* (68.33)	15.83	9.17	5.83	**12.02429* (42.49857)**
	Shaft 3	10.5 (52.5)	8.83* (44.17)	13.5* (67.5)	11.33* (56.67)	10.83	10.83	3.33	**9.87857* (35.11857)**
Homomorphic	***Shaft 1***	11.17* (55.83)	12.17* (60.83)	13.67* (68.33)	9.33* (46.67)	2.5	0	1.67	**7.22* (33.69)**
	Shaft 2	9.62* (48.08)	8.5* (42.5)	12* (60)	8.17* (40.83)	3.33	1.67	3.33	**6.66* (28.53429)**
	Shaft 3	11.67* (58.33)	8.5* (42.5)	9.17* (45.83)	8.67* (43.33)	5	0	1.67	**6.38286* (28.09429)**
Tan and Triggs	***Shaft 1***	12.33* (61.67)	6.67* (33.33)	12* (60)	9.83* (49.17)	7.5	3.33	23.33	**10.71286* (34.04714)**
	Shaft 2	9.17* (45.83)	12.67* (63.33)	11* (55)	9.17* (45.83)	0.83	15.83	9.17	**9.69143* (33.68857)**
	Shaft 3	10.5* (52.5)	9* (45)	8.17* (40.83)	10.17* (50.83)	0	21.67	16.67	**10.88* (32.5)**
Wavelet	***Shaft 1***	10.5* (52.5)	17* (85)	8* (40)	9.5* (47.5)	5.83	10	5.83	**9.52286* (35.23714)**
	Shaft 2	12.5* (62.5)	17.17* (85.83)	21.83* (68.33)	10.5* (52.5)	10.83	11.67	5	**12.79* (42.38)**
	Shaft 3	6.16* (30.8)	11.33* (56.67)	8.67* (43.33)	12* (60)	8.33	23.33	7.5	**11.04571* (32.85143)**
	Average	**11.007066* (55.03533)**	**11.47773* (57.38867)**	**11.711* (58.554)**	**10.61107* (53.05533)**	**6.832**	**11.11067**	**10.55533**	

Generally, it can be observed that a higher number of classes/nodes for a test combination results in a lower percentage of individuals with all hair clustered in the same node (e.g. Leica 1000 Wavelet Shaft 3). Each microscope system had similar percentage of individuals with all hair in the same class, with the exception of the Olympus CX31 with a 10x objective lens and 10 hairs per individual, which had a considerably lower percentage at an average of 6.832. The percentage is not observed to be affected by hair region. The normalization filters were consistent, with the exception of the homomorphic-filtering-based-normalization technique, which had a considerably lower percentage than the others.

As expected, a larger number of hairs per individual resulted in a lower percentage of individuals with all hair in the same class as variation generally increases with a larger sample size and therefore more hairs may be assigned to different classes. Theoretically, this could mean a higher percentage of well-classified hairs as more variation within an individual is accounted for with a higher sample size per individual. This hypothesis was tested with the next statistical analysis.

5.3. CHi-square Automatic Interaction Detection (CHAID) Reclassification Tree

The CHi-square Automatic Interaction Detection (CHAID) Reclassification Tree was used to find the percentage of well-classified hairs, or ratio of the number of hairs that have been well classified over the total number of hairs, for each test combination. A confusion matrix is calculated to display both the well- and poorly-classified hairs for each test combination, along with the percentage of well-classified hairs. The percentage of well-classified hairs from the confusion matrices of each of the test combinations is recorded in Table 8. Due to the size of the confusion matrices for each test combination, they were not included in this report.

As with the results of Agglomerative Hierarchical Clustering (AHC), in order to compare all test combinations, corrected values were calculated for the confusion matrix due to the imbalance in number of hairs per test combination. For the 375 test combinations with only two hairs per individual, values within parentheses are the original percentages. The values ending with an asterisk, *, are the corrected values. These values are equal to the value in the parentheses divided by 5 to represent the theoretically expected value had there been 10 hairs for that test combination rather than two.

Table 8: *Results and averages of CHAID Reclassification Tree confusion matrix*

		Leica 1000	Leica 6000	Lomo	Olympus 10x – 2 Hairs	Olympus 10x – 10 Hairs	Olympus 40x Montaged	Olympus 40x Selected	*Average*
No Filter	***Shaft 1***	5.08* (25.42)	5.17* (25.83)	5.83* (29.17)	5.92* (29.58)	11.42	11.75	11.17	**8.05* (20.62)**
	Shaft 2	5.17* (25.83)	4.75* (23.75)	6.58* (32.92)	5.83* (29.17)	11.58	11.33	12.33	**8.22* (20.99)**
	Shaft 3	5.58* (27.92)	5.08* (25.42)	5.92* (29.58)	6.33* (31.67)	10.75	11.17	11.50	**8.05* (21.14)**
Gradientfaces	***Shaft 1***	3.67* (18.33)	3.42* (17.08)	3.5* (17.50)	4.08* (20.42)	8.75	7.92	7.92	**5.61* (13.99)**
	Shaft 2	3.92* (19.58)	4.17* (20.83)	3.5* (17.50)	3.42* (17.08)	8.00	8.92	7.00	**5.56* (14.13)**
	Shaft 3	3.75* (18.75)	3.33* (16.67)	3.08* (15.42)	3.67* (18.33)	8.42	7.83	7.25	**5.33* (13.24)**
Homomorphic	***Shaft 1***	5.92* (29.58)	5.92* (29.58)	9.17* (30.42)	6.25* (31.25)	10.08	10.00	9.92	**8.18* (21.55)**
	Shaft 2	5.5* (27.50)	6.75* (33.75)	5.83* (29.17)	5.92* (29.58)	10.42	10.75	10.42	**7.94* (21.65)**
	Shaft 3	6.08* (30.42)	6.08* (30.42)	6.17* (30.83)	5.67* (28.33)	10.00	10.17	10.17	**7.76* (21.48)**
Tan and Triggs	***Shaft 1***	3.75* (18.75)	4.83* (24.17)	4.33* (21.67)	3.92* (19.58)	9.83	8.33	7.25	**6.03* (15.65)**
	Shaft 2	3.92* (19.58)	4.58* (22.92)	4.25* (21.25)	2.92* (14.58)	9.58	7.25	8.17	**5.81* (14.76)**
	Shaft 3	3.75* (18.75)	4.08* (20.42)	3.17* (15.83)	3.42* (17.08)	10.17	7.33	7.67	**5.66* (13.89)**
Wavelet	***Shaft 1***	4.42* (22.08)	5.83* (29.17)	4.83* (24.17)	4.59* (22.92)	9.75	6.58	6.33	**6.05* (17.29)**
	Shaft 2	4.92* (24.58)	5.17* (25.83)	4.83* (24.17)	5* (25.00)	10.67	6.75	7.08	**6.35* (17.73)**
	Shaft 3	4.58* (22.92)	5.83* (29.17)	4.92* (24.58)	4.75* (23.75)	9.75	7.17	7.08	**6.3* (17.78)**
Average		**4.67* (23.33)**	**5.00* (25.00)**	**4.86* (24.28)**	**4.78* (23.89)**	**9.94**	**8.88**	**8.75**	

As hypothesized from the AHC results, the Olympus CX31 microscope with 10x objective lens and 10 hairs per individual yielded the highest average percentage of well-classified hairs at 9.94%. Generally, it can be observed that test combinations with 10 hairs per individual yielded higher average percentages than the corrected percentages of the test combinations with two hairs per individual. As seen in the AHC results, hair region does not appear to affect the percentages. The non-filtered and homomorphic-filtering-based normalization techniques yielded the highest average percentages, with the highest average occurring for the non-filtered, Olympus CX31, 10x objective lens, 10 hairs per individual percentages.

The percentages are exponentially related to the number of individuals examined. Table 9 displays the results of decreasing the population size using the non-filtered, Olympus CX31, 10x objective lens, 10 hairs per individual, Shaft 1 percentage. Calculations were done by selecting 10 groups randomly for each population size, except for the population size of 120, and averaging the percentage of well-classified hairs. These results demonstrate that larger populations will most likely yield a lower percentage of well-classified hairs. Therefore, it can be concluded that a smaller sample size of individuals will yield more accurate classification results.

__Table 9:__ Effect of Population Size on Percentage of Well-Classified Hairs using Olympus CX31, 10x objective lens, No Filter, Shaft 1 Test Combination

Population Size	Percentage of Well-Classified Hairs
120	11.42%
60	19.53%
30	30.34%
15	49.38%
5	81.92%

6. GENERAL DISCUSSION

The results of the one-way Analysis of Variance (ANOVA), Agglomerative Hierarchical Clustering (AHC) and CHi-square Automatic Interaction Detection (CHAID) Reclassification Tree analyses were used to make inferences regarding the performance of the test combinations on the maternal groups and of the variables that make up those test combinations. A recommendation for a texture-based image analysis method, using a particular test combination, on human head hair samples could be made.

6.1. Maternal Relationships

Analysis of Variance (ANOVA) results for each of the six maternal groups using the Olympus CX31 – 10x objective lens – 10 hairs – shaft 1 – no filter combination, determined to yield the highest percentage of well-classified hairs among all test combinations, can be found in Appendix E. The summary of those results can be found in

Table 10, where ‘Y’ indicates ANOVA results which yielded F-values greater than the F critical value and p-values less than 0.05. More than half of the results cannot reject the null hypothesis that the means of each individual are the same as the rest of maternal group. Specifically, 41.67% of the results reject the null hypothesis. This amount is considerably lower than the 89.05% found when considering all 420 test combinations evaluating all 120 individuals. This supports the hypothesis that the ratio of within-individual variation to between-individual variation is smaller for maternal groups than the entire population of 120 individuals.

Table 10: *Summary ANOVA Results for Maternal Groups using the Olympus CX31 – 10x Objective Lens – 10 Hairs – Shaft 1 – No Filter Test Combination*

	Contrast	**Correlation**	**Energy**	**Homogeneity**
Group 1	N	**Y**	**Y**	**Y**
Group 2	N	**Y**	**Y**	N
Group 3	N	N	N	**Y**
Group 4	N	**Y**	N	**Y**
Group 5	N	N	N	N
Group 6	N	**Y**	**Y**	N

Agglomerative Hierarchical Clustering (AHC) results did not yield a higher or lower number of classes, as compared to the overall AHC results. Furthermore, hairs of each of the individuals did not cluster in a single class, nor did they demonstrate a particular pattern among their maternal groups, as compared against the rest of the population.

The CHi-square Automatic Interaction Detection (CHAID) Reclassification Tree yielded more telling results. It was hypothesized that these results would have a lower percentage of well-classified hairs, as compared to the overall results from all 120 individuals. The results for the CHAID Reclassification Tree confusion matrix results can be found in Table 11. The hypothesis can be rejected due to the high percentage of well-classified hairs among each maternal group. When performing the CHAID Reclassification Tree analysis on all 20 individuals among the maternal groups, the percentage of well-classified hairs is 40%. This corresponds well with any 20 individuals selected for comparison among the 120 individuals within the population, as shown in Table 9.

Table 11: *CHAID Reclassification Tree Confusion Matrix Results for Maternal Groups using the Olympus CX31 – 10x Objective Lens – 10 Hairs – Shaft 1 – No Filter Test Combination*

Group Number	Group Size	Percentage of Well-Classified Hairs
1	5	90%
2	3	93.33%
3	4	90%
4	3	93.33%
5	2	100%
6	3	93.33%

The results of the CHAID Reclassification Tree confusion matrix indicate that it could be possible to use this method of image analysis when mitochondrial DNA analysis would fail to discriminate hairs of an individual from other members of the same maternal group. Further testing involving the other test combinations and more maternal groups, including some with a higher number of members, will need to be evaluated for verification of these results.

6.2. Microscope Systems

The first variable of the test combinations evaluated was the microscope system used. Four microscope systems were evaluated: Leica DM6000B compound microscope with a Leica DFC300 FX camera, Leica DM1000 with a Canon EOS Revel XT digital camera, LOMO POLAM L-213M compound microscope with a Nikon D90 digital camera, and an Olympus CX31 compound microscope with a Nikon D90 digital camera. The purpose of including different microscope systems was not to evaluate which system was best, as it is not the intention of this research to endorse a microscope or camera manufacturer. The purpose was to replicate the other variables in the test combinations with a variety of microscope systems for reproducibility and repeatability. This was attempt to account for some of the variability of systems that may be contained in different forensic laboratories.

The ANOVA results for the four different microscope systems are shown in Figure 25. Along with F-values for each system, the mean for each is also included in order to better compare the systems. From the plot we are able to see that all trend lines fall above the F critical value, labeled as a black line. This means that the null hypothesis is rejected in most cases, despite the microscope system used. That being said, two of the systems are observed to have a greater difference in means between the individuals. These two systems are the Lomo and Leica DM6000B systems.

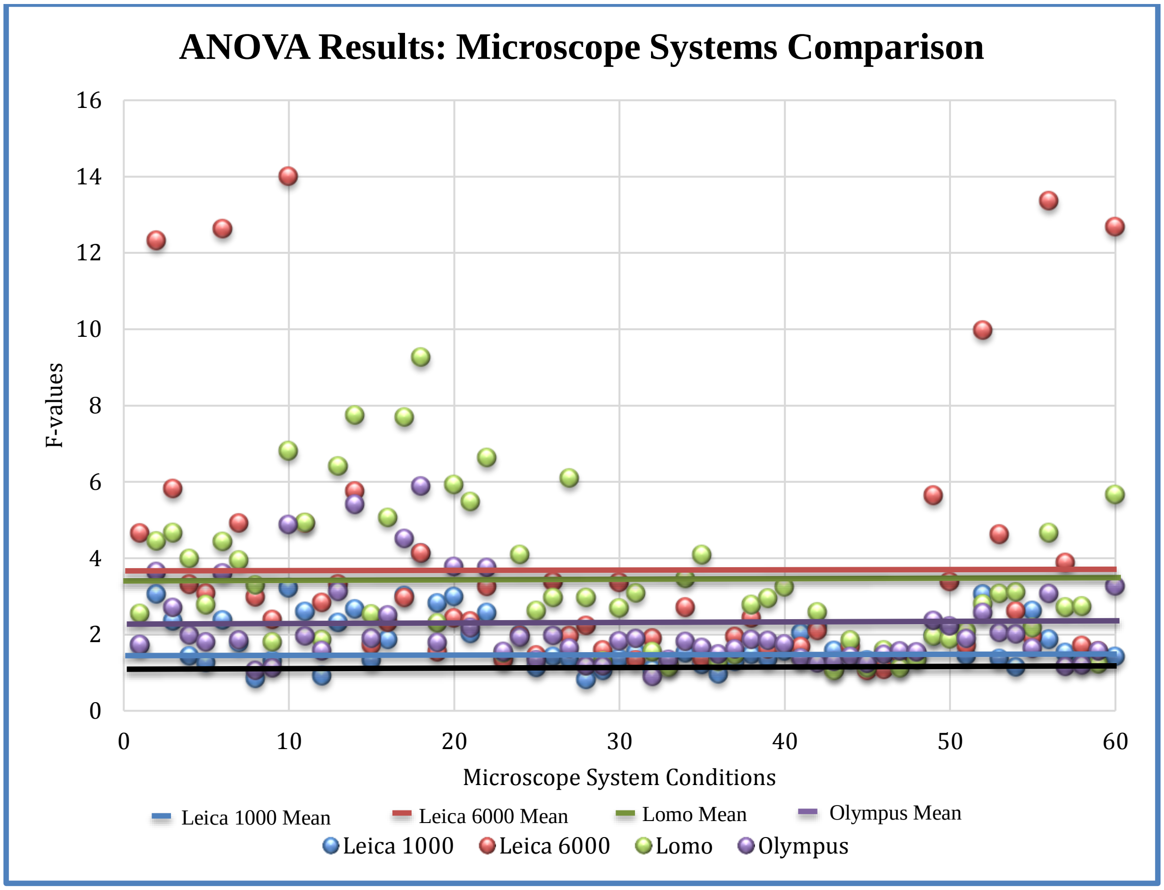

Figure 25: *ANOVA results comparing the different microscope systems. Each data point represents 2-hair results. The black line indicates the F critical value.*

The results of the CHAID Reclassification Tree confusion matrix can be observed in Figure 26. As shown in this graph, no microscope system are clearly more effective than the other. This observation put the focus of the study on the other variables.

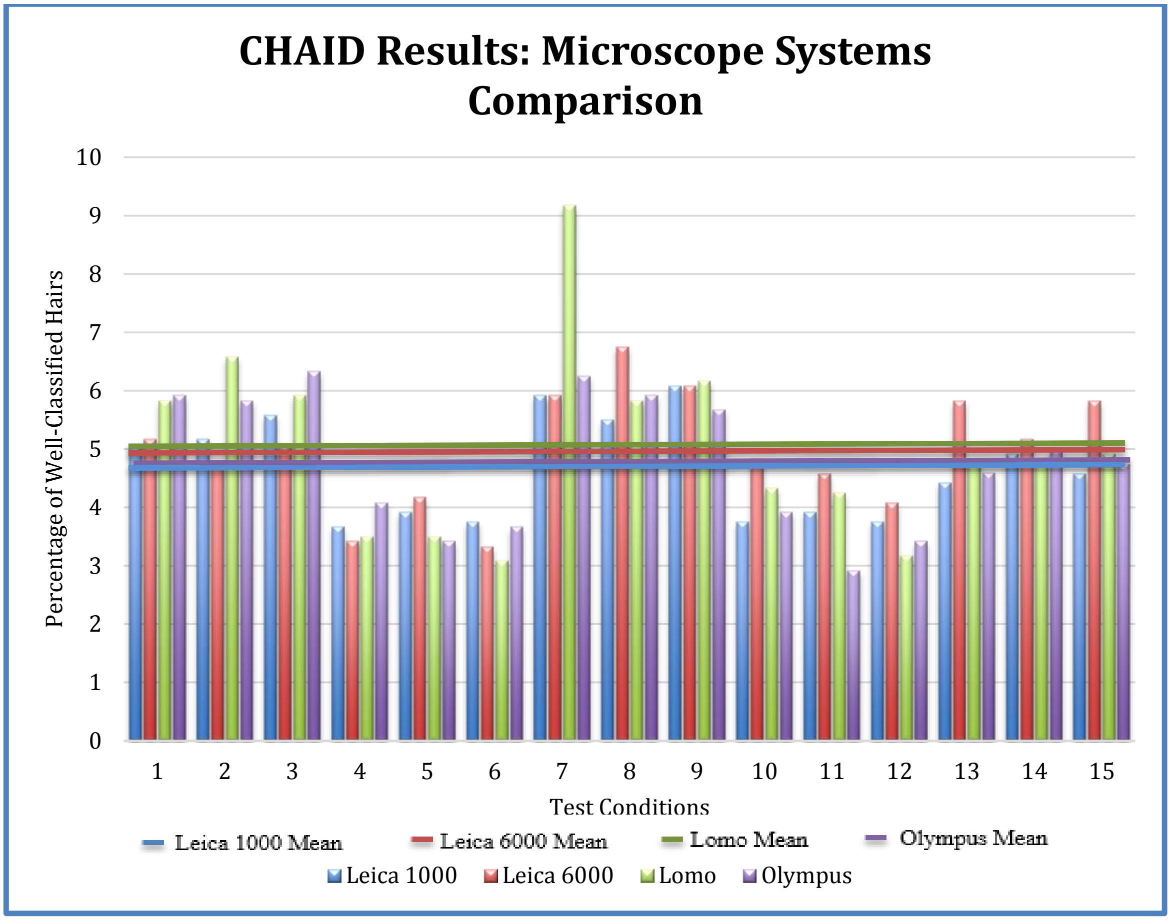

Figure 26: *CHAID Reclassification Tree confusion matrix results comparing the different microscope systems. Each bar represents 2-hair results.*

6.3. Objective Lenses

The second variable evaluated was the objective lens used. The Olympus CX31 system was chosen to evaluate the 10x and 40x objective lenses, based on preliminary results that indicated that this system was the most effective. The hypothesis was that the 10x objective lens would show more variation in an individual, due to the larger portion of the hair observed in each image. The 40x objective lens, on the other hand, would yield more details, as the hair would encompass more pixels in the image, but would not encompass the variation of the 10x objective lens images.

The results of ANOVA are illustrated in Figure 27. From the plot we are able to see that both mean lines and most data points fall above the F critical value, meaning that the null hypothesis is rejected in most cases, despite what objective lens is used. It can also be clearly observed that 40x objective lens generally has higher F-values. According to these results, the image under a 40x objective lens have a greater difference between the means of the individuals than under the 10x objective lens.

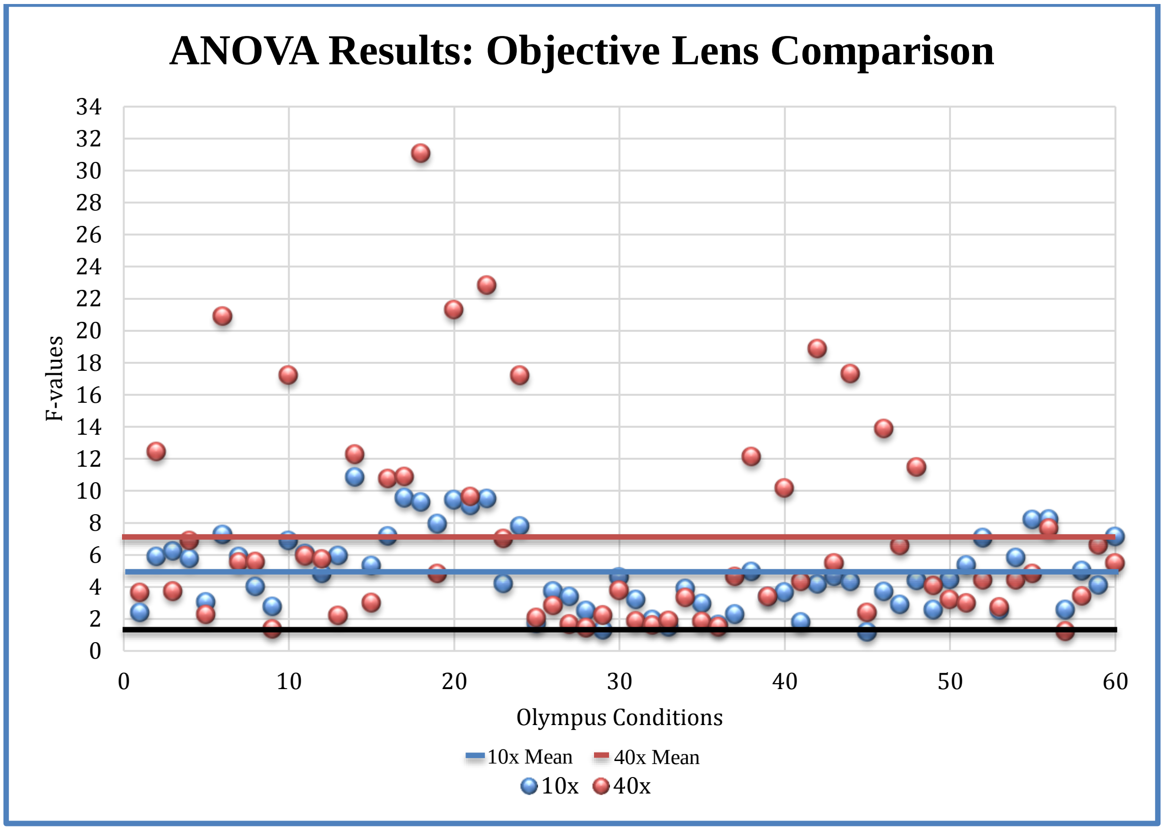

Figure 27: *ANOVA results for the different objective lenses used. Each data point represents 10-hair results. The black line indicates the F critical value.*

The results for the CHAID Reclassification Tree confusion matrix can be found in Figure 28. The means lines and general observation of the bars in the graph indicate that the images taken with a 10x objective lens yielded higher percentage of well-classified hairs than images taken with a 40x objective lens. This was not the case for all of the test conditions.

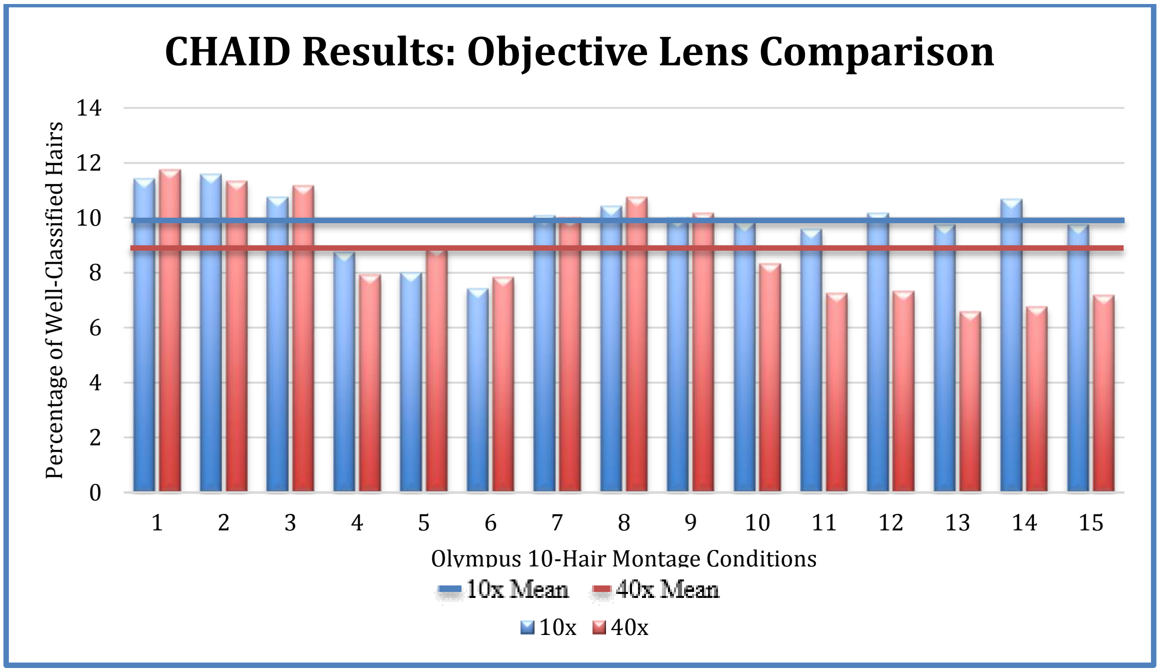

Figure 28: *CHAID Reclassification Tree confusion matrix results comparing the different objective lenses used. Each bar represents 10-hair results.*

6.4. Number of Hairs Per Individual

The next variable evaluated was the number of hairs evaluated per individual. It is generally accepted within the forensic community that a larger number of hairs per individual should be tested in order to account for all of the variation of hair in an individual. Therefore, it was hypothesized that the test combinations containing 10 hairs per individual would not only yield a higher percentage of well-classified hairs, because more variation is accounted for, but that this variation would cause the 10 hair test combinations to yield higher F-values demonstrating a greater difference of means in each individual.

The results of ANOVA for the objective lenses are illustrated in Figure 29. The mean lines are not necessary to observe that the test combinations containing 10-hair samples yielded higher F-values overall. This observation supports the hypothesis.

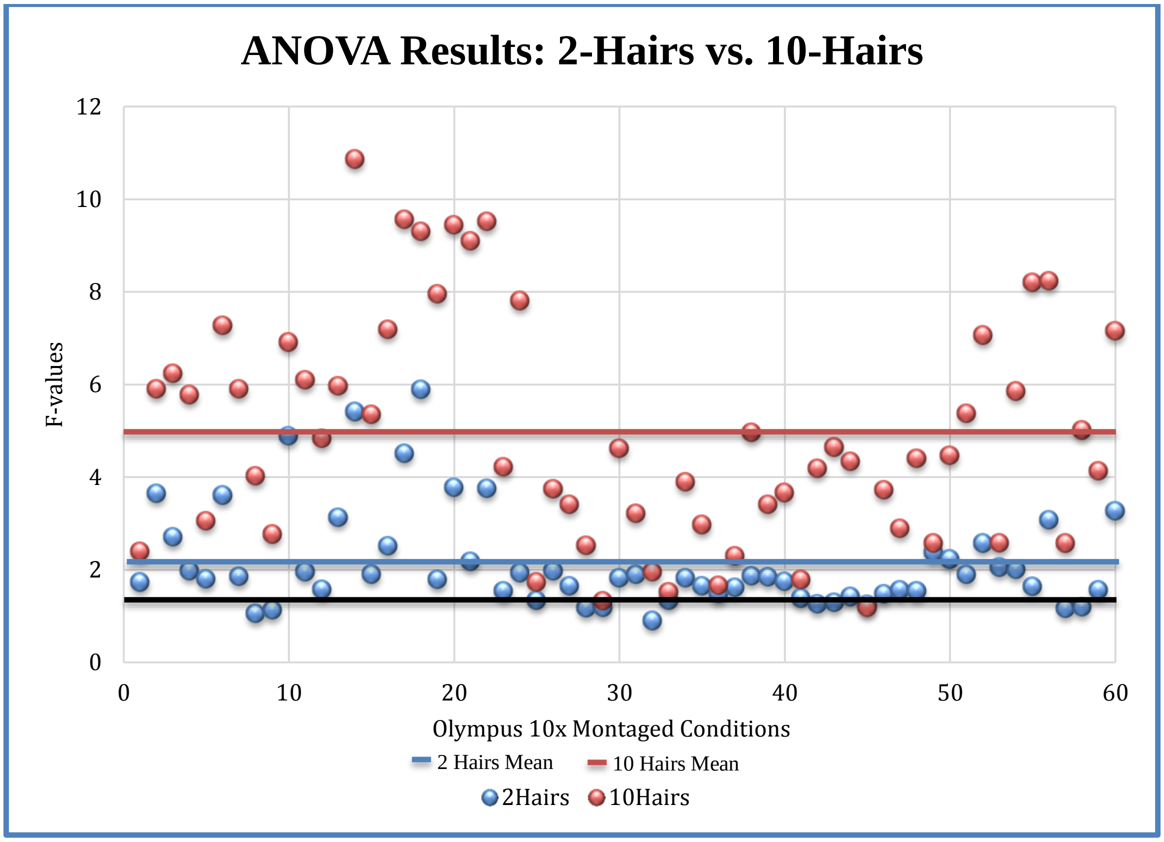

Figure 29: *ANOVA results for the different number of hairs per individual used. Each data point represents Olympus, montaged, 10x objective lens results. The black line indicates the F critical value.*

The CHAID Reclassification Tree confusion matrix results can be found in Figure 30. Again it is clear that the test conditions containing 10-hairs yielded a greater percentage of well-classified hairs. This was true in every case illustrated in Figure 30. More hairs per individual were used to encompass more variation found within an individual. Perhaps if more hairs per individual were tested, the percentages would have been even higher.

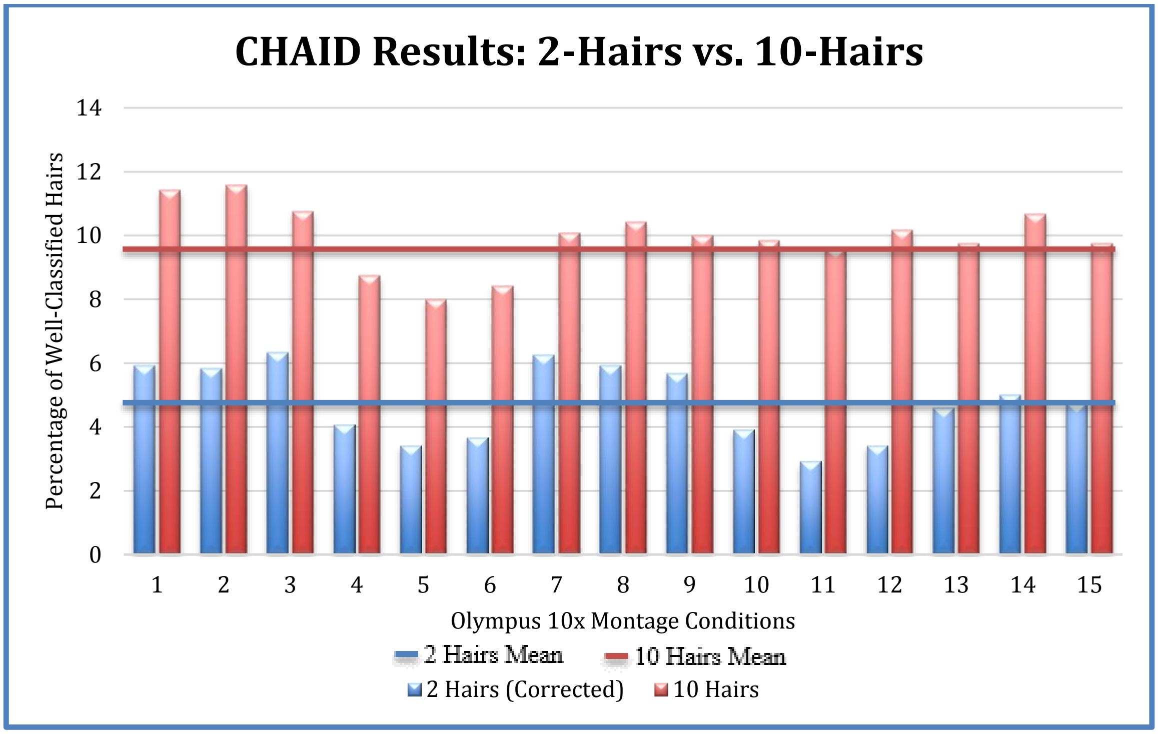

Figure 30: *CHAID Reclassification Tree confusion matrix results comparing the different number of hairs used. Each bar represents an Olympus, montaged, 10x objective lens result.*

6.5. Hair Shaft Regions

An important characterization of the human head hair shaft is the pigmentation pattern. When the follicle is nearing the end of its growth cycle, melanin formation and formation of the medulla simultaneously stop. Hence, the last segment of hair that grows is colorless and unmedullated, while the first segments have a higher concentration of pigments and are possibly, but not necessarily, medullated [5]. Based on this information, it was hypothesized that the Shaft 3 would yield lower F-values and lower percentages well-classified hairs, due to the absence or low concentration of pigmentation. Shaft 2 was hypothesized to yield the highest F-values and percentage of well-classified hairs, due to possible high-concentration of pigments that may decrease the variation seen between hairs.

The ANOVA results for the hair shaft regions can be found in Figure 31. The mean lines allow for the observation of overall higher F-values for images include the Shaft 2 region. This supports the hypothesis that Shaft 2 would yield higher F-values, the hypothesis regarding Shaft 3 cannot be readily supported.

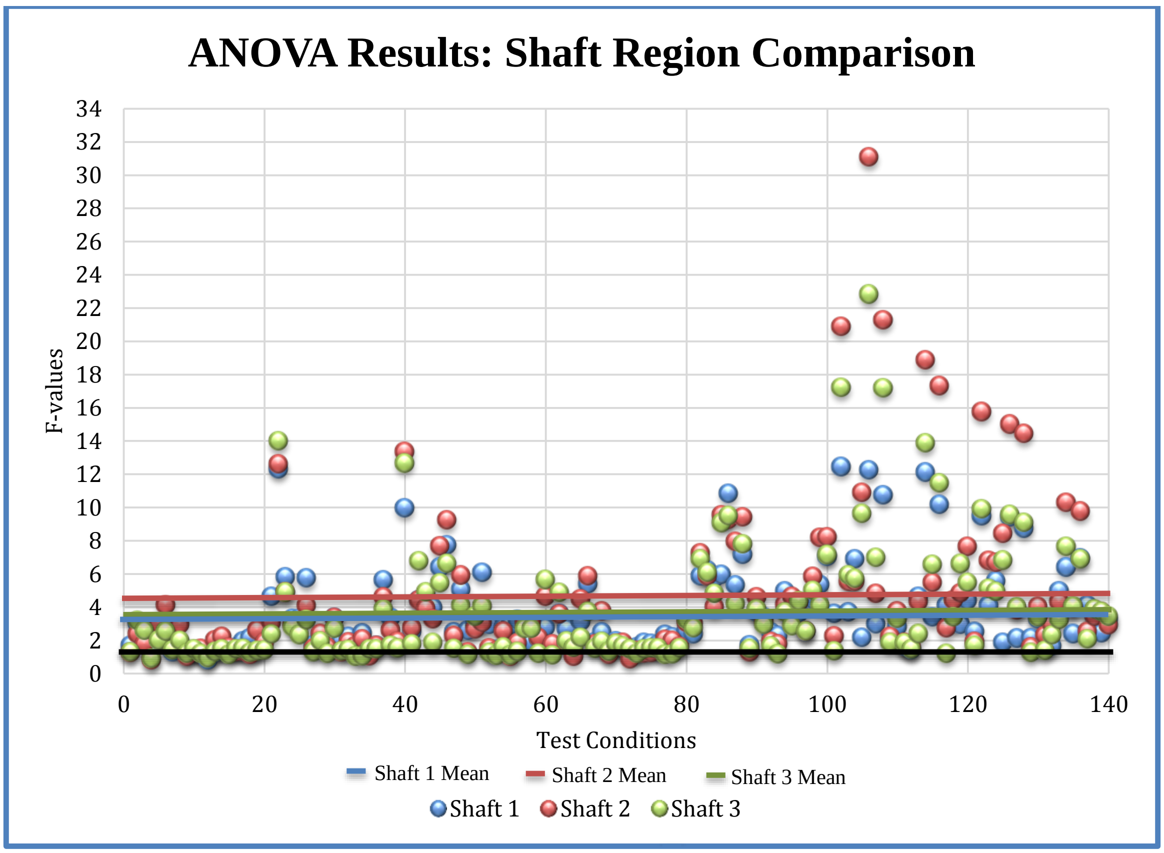

Figure 31: *ANOVA results for the different shaft regions used. The black line indicates the F critical value.*

The CHAID Reclassification Tree confusion matrix results, found in Figure 32, do not indicate a shaft region that clearly has consistently higher percentages of well-classified hairs. The mean lines, however, does show a slight decrease in percentages for Shaft 3, as compared to the other two regions. This supports the hypothesis that the region furthest from the root, and therefore containing less pigmentation, would yield overall lower percentages. This is weakly supported, however, and requires further testing for verification.

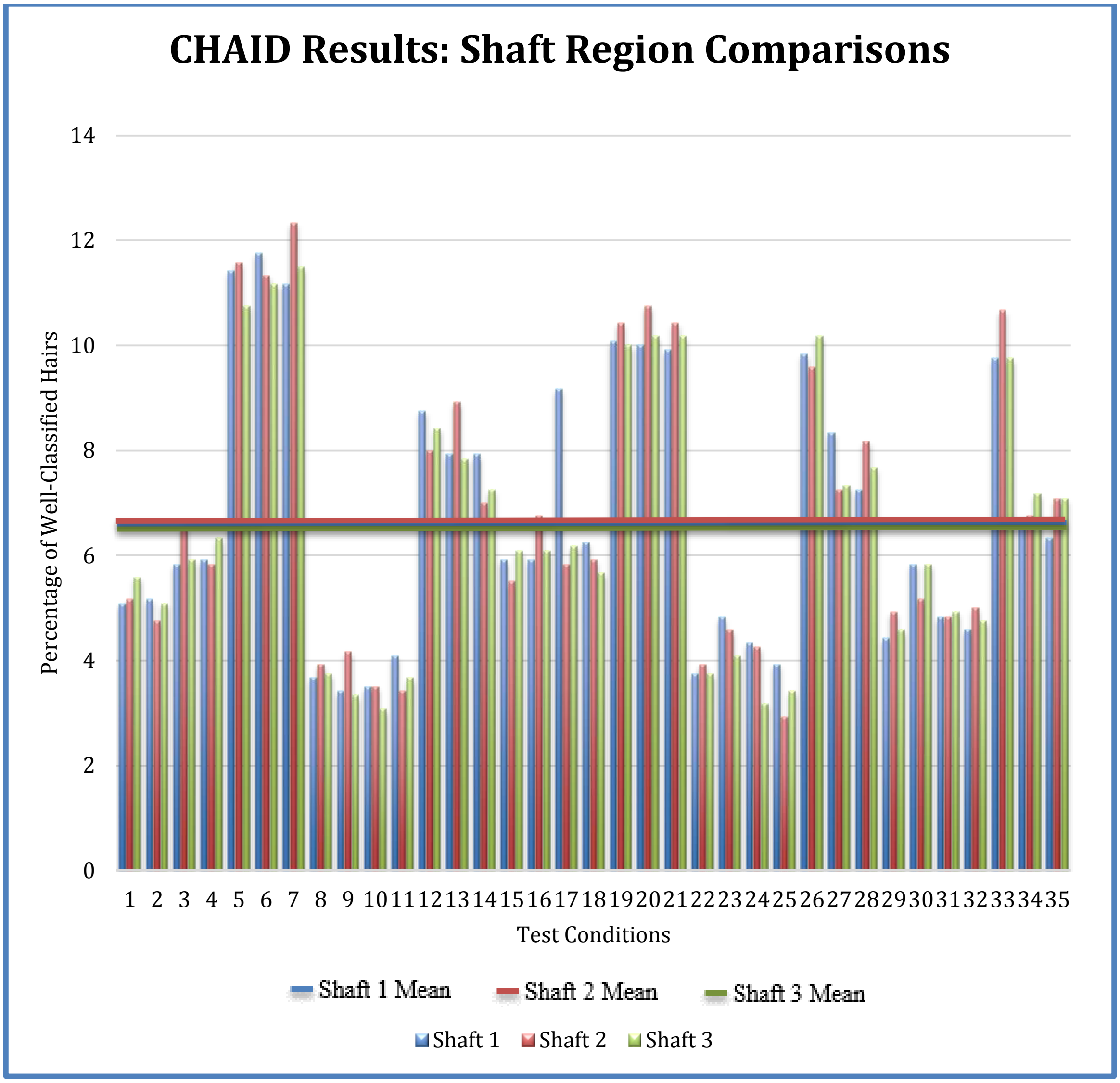

Figure 32: *CHAID Reclassification Tree confusion matrix results comparing the different shaft regions used.*

6.6. Focus Methods

The three-dimensionality and the relatively large thickness of hair poses a focusing issue for photomicrographs taken with a microscope. This study concentrated on two methods of obtaining a well-focused image. The first was to manually adjust the fine focus knob to find the closest point at which the entire hair is in focus. The second was to use a third-party program, Auto-Montage Pro (Syncroscopy, Cambridge, United Kingdom), to automatically montage or merge the images of the hair at different focal planes. The hypothesis was that the montaging would yield higher quality images, and therefore reveal more variation within an image. Therefore, it was also hypothesized that montaged images yield higher F-values and percentage of well-classified hairs.

The ANOVA results for the focus methods are illustrated in Figure 33. The means support the hypothesis. The montaged images yielded higher F-values, on average, demonstrating a greater difference among the means of the individuals. As shown by the individual data points, both focus methods yielded F-values greater than the F critical value, for the most part.

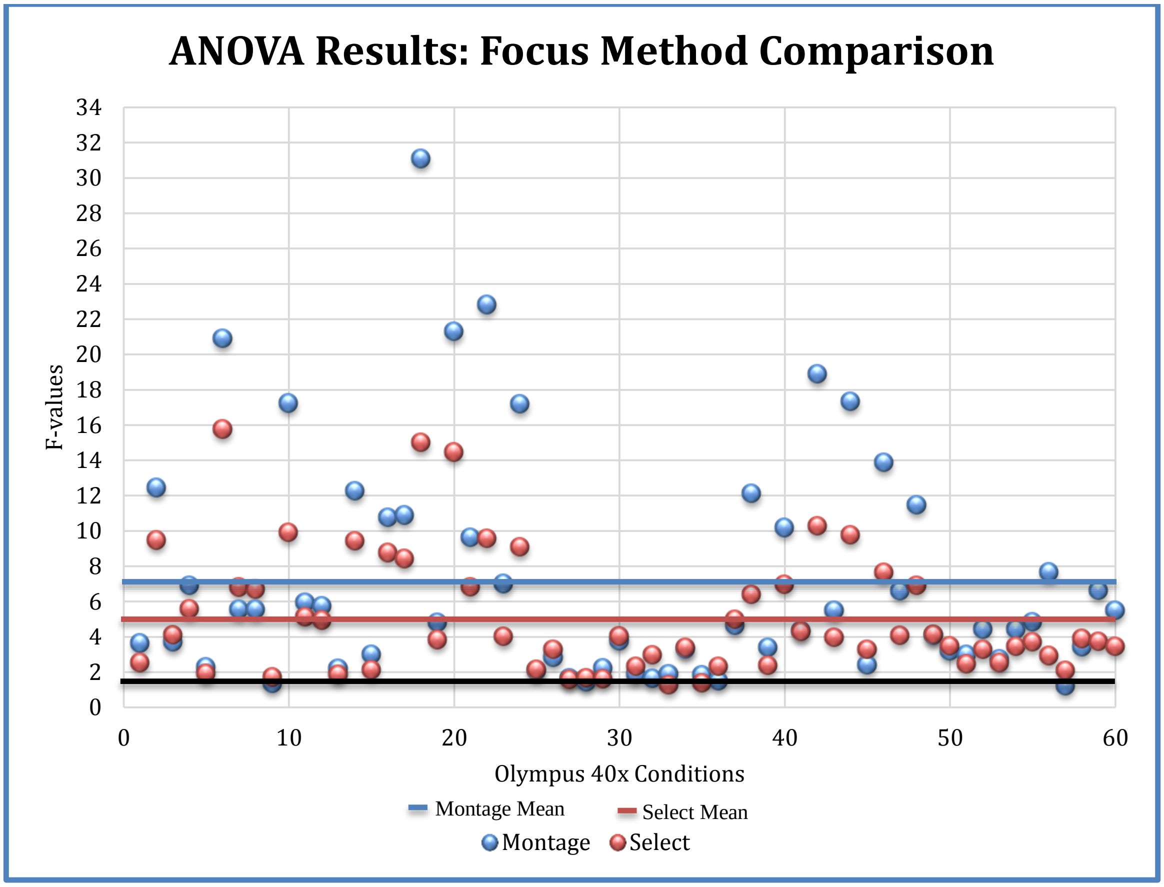

Figure 33: *ANOVA results for the different focus methods used. Each data point represents Olympus, 40x objective lens, 10-hair results. The black line indicates the F critical value.*

The CHAID results for the focus methods are illustrated in Figure 34. Neither focus method appears to yield higher or consistent percentages of well-classified hairs. Therefore, the hypothesis can be neither accepted, nor rejected. Further testing with different test combinations may reveal a greater difference between the focus methods.

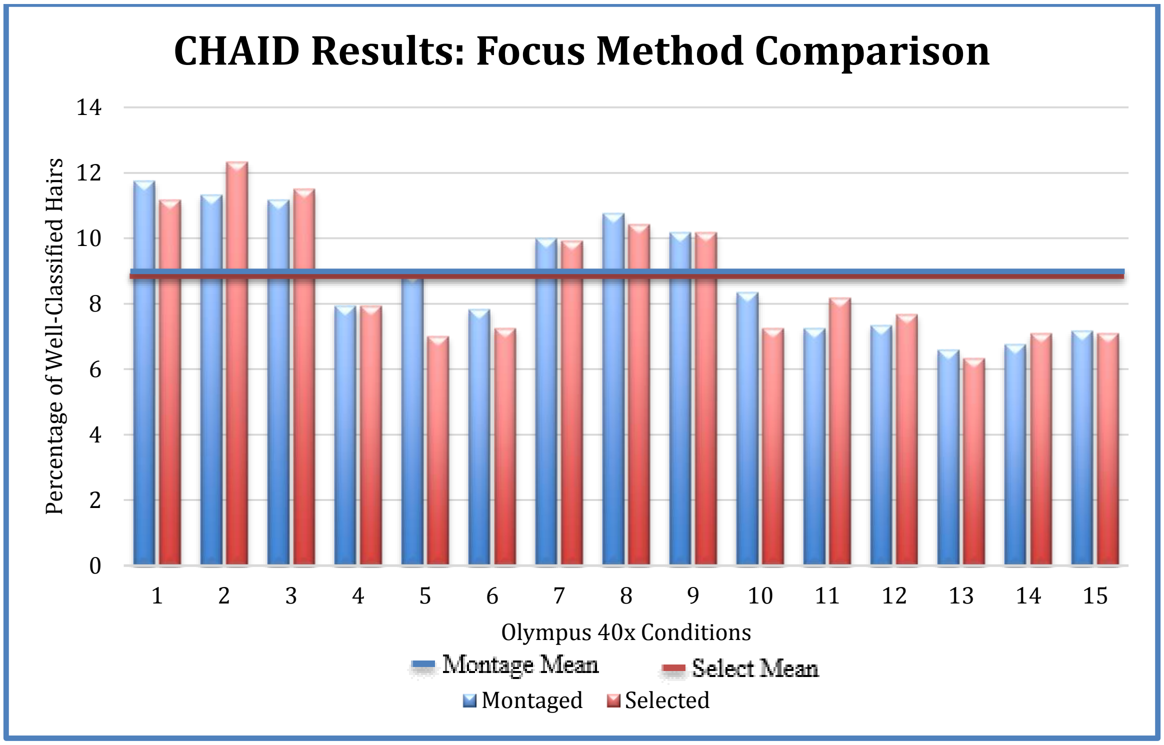

Figure 34: *CHAID Reclassification Tree confusion matrix results comparing the different focus methods used. Each bar represents an Olympus, 40x objective lens, 10-hair results*

6.7. Normalization Filter Techniques

Four normalization techniques from the INFace toolbox v2.0 (Vitomir Štruc, University of Ljubljana, Ljubljana, Slovenia) were used as filters for the hair images. The images with these filters were compared with images with different filters or no filter at all. The hypothesis regarding the normalization filter techniques was that one or more of the filters would yield a higher F-value and percentage of well-classified hairs, as compared to the images where no filter is applied.

The ANOVA results for the different filters are illustrated in Figure 35. Though not consistently greater than the other filters, the Gradientfaces normalization technique yielded the highest F-values, according to the means. The homomorphic-based-filtering normalization technique was had the lowest F-values on average, but were still mostly above the F critical value and more consistent, in comparison to the others. These results support the hypothesis regarding the F-values.

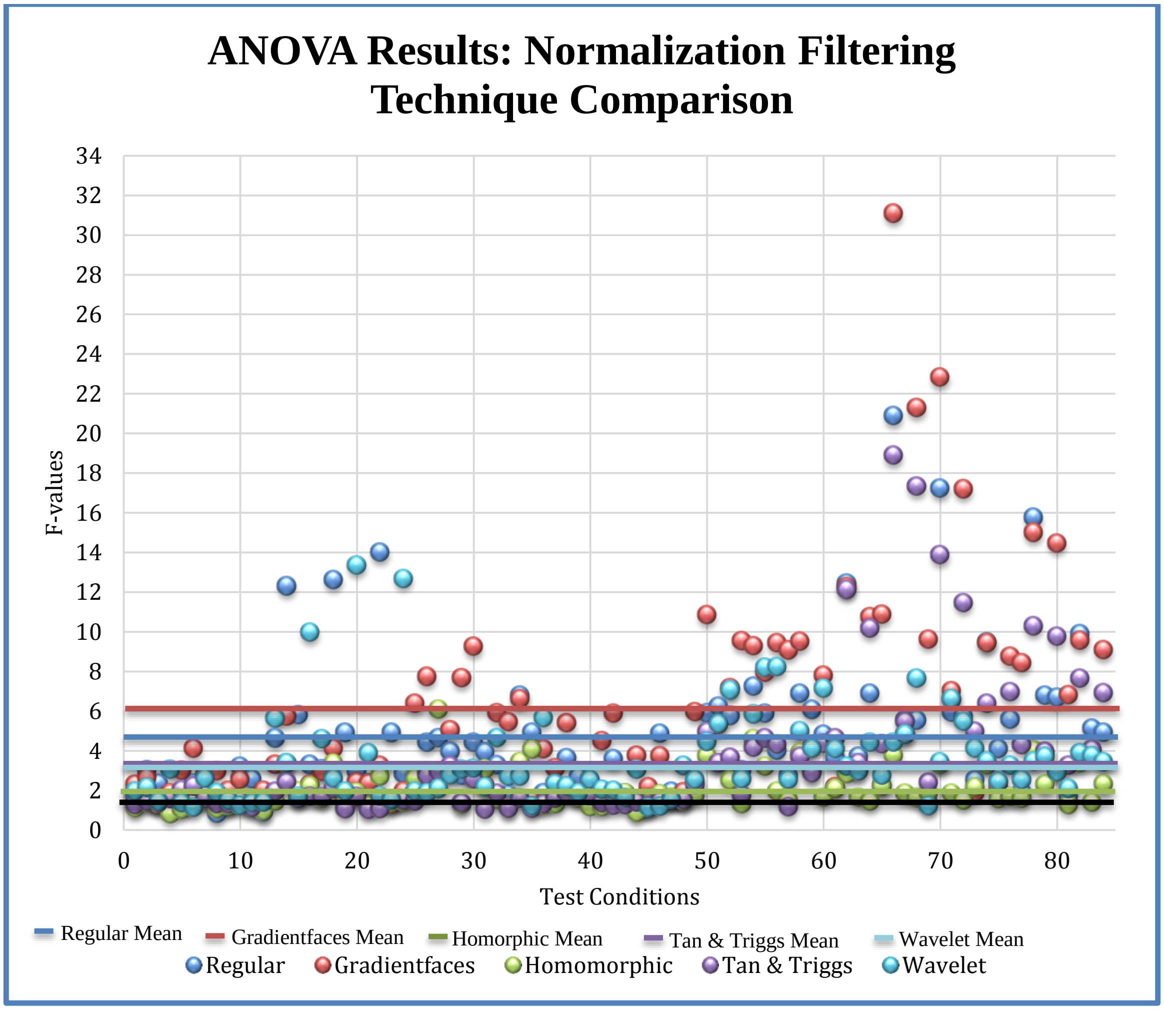

Figure 35: *ANOVA results for the different normalization filter techniques used. The black line indicates the F critical value.*

The hypothesis regarding normalization filtering techniques cannot be accepted or rejected based on the CHAID Reclassification Tree confusion matrix, illustrated in Figure 36. The bars and mean lines reveal two normalization techniques that have considerably higher percentages of well-classified hairs than the other techniques. These techniques are Homomorphic-based-filtering technique and the images containing no filter. Like the ANOVA results, the homomorphic filtering technique appears to have the most consistent results, but it is not clear whether it has overall higher results when compared to images with no filter. Therefore, the hypothesis that at least one filtering technique would yield higher percentages of well-classified hairs cannot be accepted or rejected.

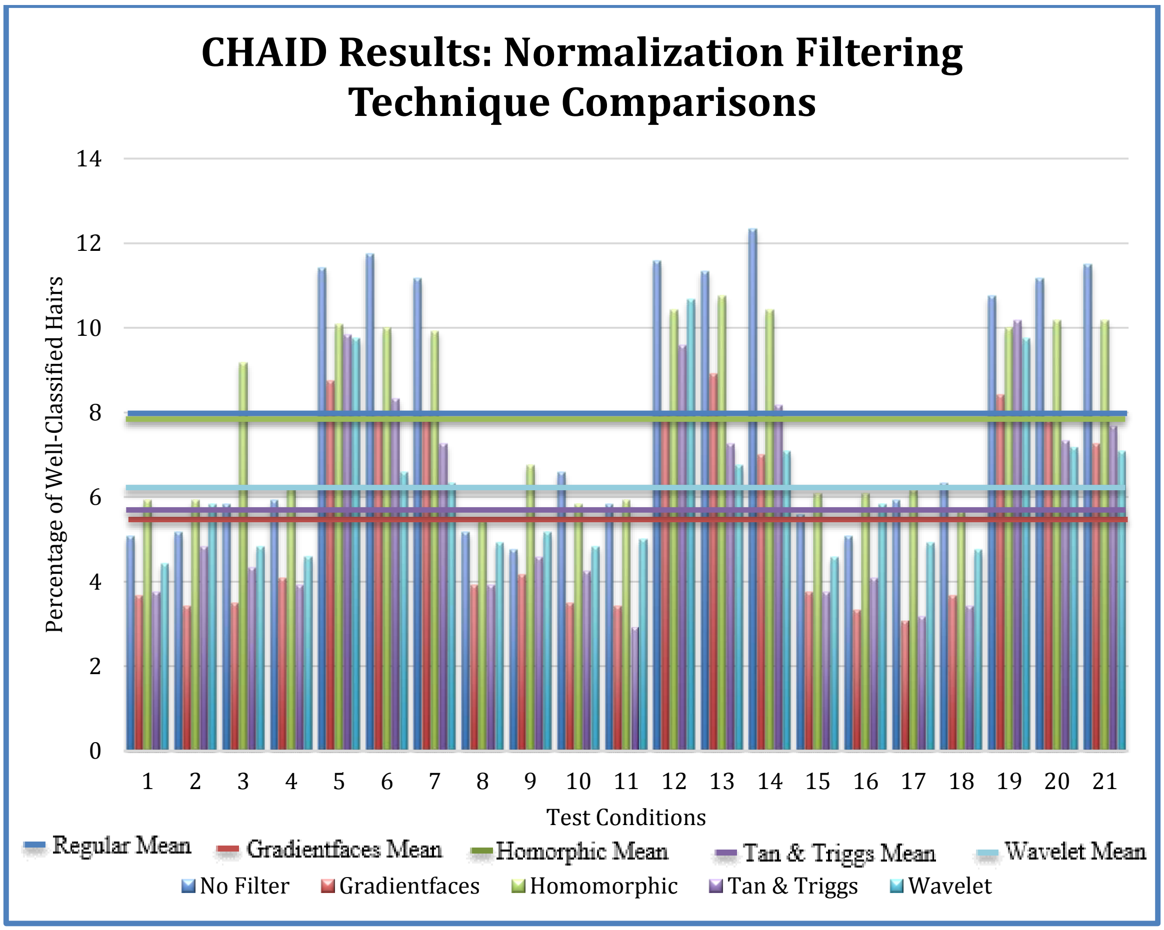

__Figure 36:__ CHAID Reclassification Tree confusion matrix results comparing the different normalization filtering techniques used.

6.8. Gray-Level Co-Occurrence Matrix (GLCM) Statistics

The final variable of the test combinations evaluated were the GLCM statistics. All four of the statistic factors are required for AHC and CHAID Reclassification Tree analyses, but the contribution of the each factor to the within-individual and between-individual variation could be observed using ANOVA. The results for the ANOVA analysis of the GLCM statistics are illustrated in Figure 37. The data points and means show higher F-values for the correlation and homogeneity values, meaning that there is a greater difference in the means between individuals for those factors. Contrast appears to have the lowest F-values, however all means lie above the F critical value, as do most of the individual data points, indicating the null hypothesis that all individuals have the same mean can be rejected.

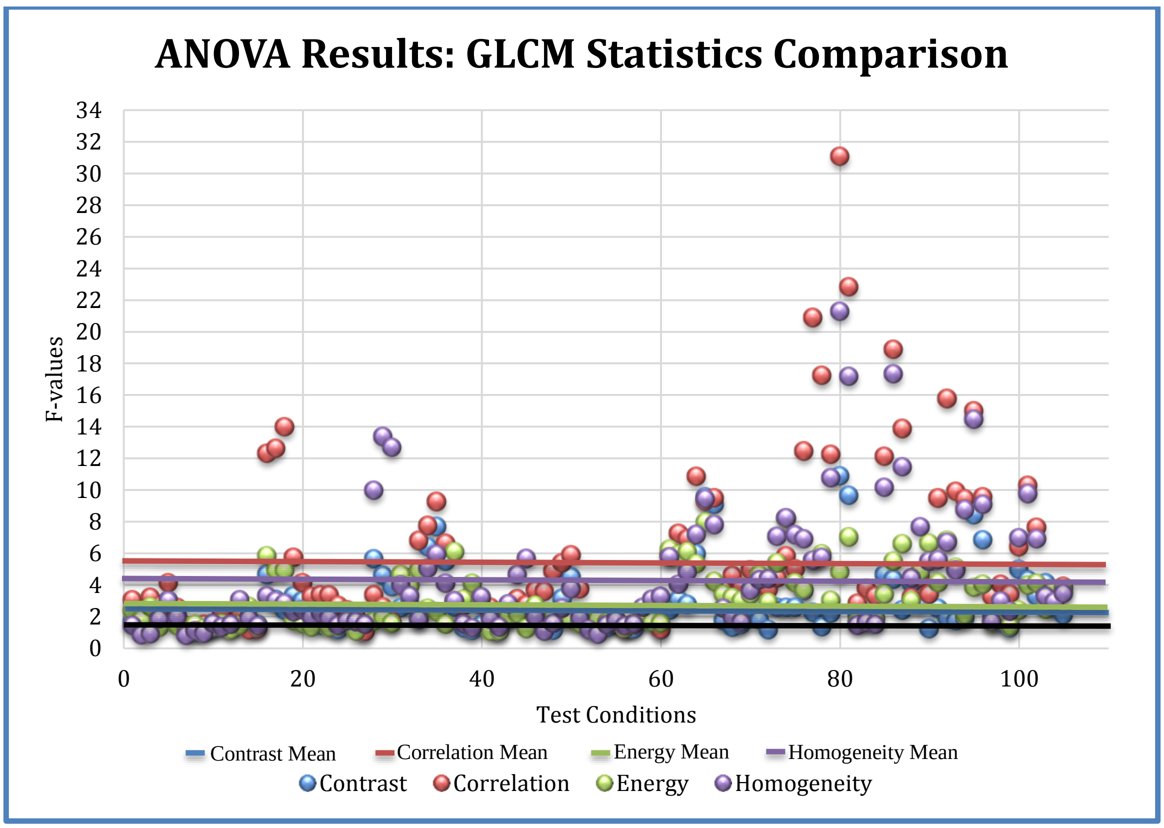

Figure 37: *ANOVA results for the different GLCM statistics. The black line indicates the F critical value.*

6.9. Suggested Protocol for Image Analysis

After evaluating the ANOVA, AHC, and CHAID Reclassification Tree results of the different test combinations, the Olympus CX31 microscope system with 10x objective lens, 10-hairs, Shaft 2, montaged, no filter test combination yielded the highest percentage of well-classified results, according to Table 8, for this method of image analysis of human head hair samples.

Every possible test combination was not performed, therefore all of the variables can be evaluated to form a theoretical best test combination. By considering all of the variables and how well they performed in the CHAID Reclassification Tree analyses, the theoretical best test combination would be any of the microscope system with a 10x objective lens, 10-hairs, Shaft 2 or Shaft 3, montaged, no filter or homomorphic-based-filtering technique combination. This was not one of the test combinations tested, therefore it should be evaluated to verify this hypothesized best test combination.

Given this information, the suggested protocol for this method of texture-based image analysis includes the following steps:

1) Capture images using compound microscope with a mounted camera and a 10x objective lens. At least 10 hairs should be used per reference individual. The shaft region in the center of each hair (Shaft 2) should be photomicrographed. Multiple images should be taken at different focal planes.

2) Montage images of different focal planes using a montaging software, such as Auto-Montage Pro (Syncroscopy, Cambridge, United Kingdom).

3) Whiten the background of each image with a paint application or photo editor.

4) Normalize images by converting the images into gray-scale; converting from gray-scale into black and white; dilating the resulting image to remove stray, isolated pixels; converting the white background into black; superimposing the black background on the gray-scale image; performing an affine rotation; and cropping out as much of the background as possible.

5) Calculate the GLCM statistics.

6) Compare GLCM statistics of unknown specimens to that of reference samples at the source level by using a statistical approach. Frequency data for features found in the population of interest, as well as the chances of observing similarities between hair samples originating from individuals, should be used.

7. CONCLUSION

With the recent admission of the Federal Bureau of Investigation on decades of flawed hair examination methods, as well as the criticism of traditional hair examination methods by the National Academy of Sciences, there is a clear need for an objective method for hair examination when nuclear and mitochondrial DNA analyses cannot be performed or do not yield results [3, 4]. This study developed and evaluated an objective method for hair examination utilizing texture-based image analysis.

Different variables were used to define the most efficient set for the method developed, in order to achieve a higher ratio of within-individual variation to between-individual variation and a higher percentage of well-classified hair. The defined and tested method included capturing images at different focal planes utilizing an Olympus CX31 compound microscope and Nikon D90 digital camera system, a 10x objective lens, at least 10 hairs per reference individual, and evaluation of the middle of the hair shaft. The method then specifies montaging the image, whitening its background, normalizing it, calculating the gray-level co-occurrence matrix (GLCM) statistics, and comparing the statistics between unknown and reference samples. This method improves with smaller population of reference individuals, as shown in Table 9.

This method was tested against six different maternal groups consisting of two to five members each, to evaluate the method's results in situations where mitochondrial DNA analysis would fail to differentiate different hairs of different individuals. Results of this test indicated that the method can be used when DNA analysis cannot be, as shown in Table 11.

Additionally, each of the variables of the test combinations were evaluated independently to obtain the most efficient, theoretical method. This includes using any compound microscope mounted with a camera, a 10x objective lens, at least 10 hairs per individual, and montaging the images. Further testing should be done to verify the efficiency of this set of variables for the method before using it over the most efficient, tested method.

8. FUTURE RESEARCH

Future research will primarily focus on further developing the most efficient, theoretical method by testing other combinations and conducting further tests to verify efficiency of the method. Frequency data for features should also be developed in order to conduct statistical interpretation of comparisons made between hair samples. Additionally, more hairs per individual can be tested, as well as more maternal groups. Further, long-term research could evaluate a method combining image, mitochondrial DNA, and traditional microscopical examinations, in order to determine the best method for human head hair examinations when nDNA does not offer promising results. Other methods of image analysis may also be applied, such as Local Binary Patterns (LBP) and Scale-Invariant Feature Transform (SIFT).

9. REFERENCES

[1] Butler, John M. *Advanced Topics in Forensic DNA Typing: Methodology*. 1st ed. Waltham, MA: Elsevier, 2012. 405-456. Print.

[2] Isenberg, A.R., and J.M. Moore. "Mitochondrial DNA analysis at the FBI laboratory." *Forensic Science Communications*. 1.2(1999): n. page. Print.

[3] National Academy of Sciences, National Research Council, Committee on Identifying the Needs of the Forensic Sciences Community, National. "5 Descriptions of Some Forensic Science Disciplines." *Strengthening Forensic Science in the United States: A Path Forward*. Washington, DC: The National Academies Press, 2009.

[4] Hsu, Spencer S. (2015, April 18). FBI admits flaws in hair analysis over decades. *The Washington Post*. Retrieved from www.washingtonpost.com

[5] Bisbing, R.E. "The Forensic Identification and Association of Human Hair." Trans. Array Forensic Science Handbook, Volume I. Richard Saferstein. 2nd ed. Upper Saddle River: Prentice Hall, 2002. 389-428. Print.

[6] Scientific Working Group on Materials Analysis (SWGMAT). "Forensic Human Hair Examination Guidelines." *Forensic Science Communications*. 7.2 (2005): n. page. Print.

[7] Deedrick, D.W., and S.L. Koch. "Microscopy of hair part I: A practical guide and manual for animal hairs." Forensic Science Communications. 6.1(2004): n. page. Print.

[8] Robertson, James. "Forensic and Microscopic Examination of Human Hair." Trans. Array *Forensic Examination of Hair*. James Robertson. 1st ed. London: Taylor & Francis, 1999. 79-133. Print.

[9] Seta, S. , H. Sato, and B. Miyake. "Forensic hair investigation." Trans. Array *Forensic Science Progress, Volume II*. A. Maehly and R.L. Williams. Berlin:

Springer-Verlag, 1988. 47-166. Print.

[10] Melton, T., G. Dimick, B. Higgins, L. Lindstrom, and K. Nelson. “Forensic mitochondrial DNA analysis of 691 casework hairs.” *Journal of Forensic Sciences*. 50.1(2005): n. page. Print.

[11] Melton, T., and K. Nelson. “Forensic mitochondrial DNA analysis: two years of commercial casework experience in the United States.” *Croatian Medical Journal*. 42.3(2001): 298-303. Print.

[12] Nixon, Mark S., and Alberto S. Aguado. *Feature Extraction & Image Processing for Computer Vision*. 3rd ed. London: Academic Press, 2012. Print.

[13] Russ, J.C. "The Image Processing Handbook." 6th ed. Boca Raton: CRC Press, 2011. Print.

[14] Verma, M.S., L. Pratt, C. Ganesh, and C. Medina. "Hair-MAP: A prototype automated systems for forensic hair comparison and analysis." *Forensic Science International*. 129(2002): 168-186. Print.

[15] Bednarek, J. "An attempt to establish objective criteria for morphological examinations of hairs using the image analysis system." *Problems of Forensic Sciences*. LVI(2003): 63-75. Print.

[16] Ogle, R.R., and M.J. Fox. *Atlas of Human Hair: Microscopic Characteristics*. Boca Raton: CRC Press LLC, 1999. Print.

[17] Vaughn, M.R., R.A.H. van Oorschot, and S. Baindur-Hudson. “A comparison of hair colour measurement by digital image analysis with reflective spectrophotometry.” *Forensic Science International*. 183(2009): 97-101. Print.

[18] Brooks, E., B. Comber, I. McNaught, and J. Robertson. "Digital imaging and image analysis applied to numerical applications in forensic hair examination." *Science and Justice*. 51. (2011): 28-37. Print.

[19] Sato, H. “Preliminary study of hair form of Japanese head hairs using image analysis.” *Forensic Science International*. 131(2002): 202-208. Print.

[20] Gurden, S.P., V.F. Monteiro, E. Longo, and M.M.C. Ferreira. "Quantitative analysis and classification of AFM images of human hair." *Journal of Microscopy*. 215(2004): 13-23. Print.

[21] Syncroscopy. Auto-Montage: User Manual. Cambridge, UK: Syncroscopy, 2004. Print.

[22] Struc, V. INface toolbox v2.0: Toolbox description and user manual. Ljubljana, Slovenia: Struc, 2011. Print.

[23] Gray-Level Co-Occurrence Matrix (GLCM). MathWorks. Retrieved from http://www.mathworks.com/help/images/gray-level-co-occurrence-matrix-glcm.html?refresh=true

[24] Motulsky, H. (2010). Analysis of Variance. In *Intuitive Biostatistics* (pp. 323-329). New York, NY: Oxford University Press, Inc.

[25] Dinov, I. (2015, March 4). F Distribution Tables. *University of California, Los Angeles*. Retrieved from http://www.socr.ucla.edu/applets.dir/f_table.html

[26] Running an Agglomerative Hierarchical Clustering (AHC) with XLSTAT. (n.d.). Retrieved April 1, 2015, from http://www.xlstat.com/en/learning-center/tutorials/running-an-agglomerative-hierarchical-clustering-ahc-with-xlstat.html

[27] Creating a CHAID classification tree with XLSTAT. (n.d.). Retrieved April 1, 2015, from http://www.xlstat.com/en/learning-center/tutorials/creating-a-chaid-classification-tree-with-xlstat.html

Appendix A – MATLAB Scripts

1. Matlab script for the initial normalization of images

```
% Writes in image (e.g. image '120_10_01.tif')
  img = imread('120_10_01.tif');

% Converts img to grayscale
gray = rgb2gray(img);

% Converts gray to black and white
bw = im2bw(img, graythresh(img));

% Dilates bw to remove stray, isolated pixels
bw = bwareaopen(bw, 10000);

% Converts background of bw to black
bw = imcomplement(bw);

% Superimposes the black background on the gray-scale image
fgm = imregionalmin(bw);
bw2 = gray;
bw2(fgm) = 0;

% Determines the angle between the bottom edge of hair and horizontal plane
rowmax = 2847; % dependent on size of image
colmax = 4287; % dependent on size of image
col = colmax - 1;
for i=1:(rowmax)-1
        if bw(i,col)==0
                Black_pix = [i,col]
                row = i
                break;
        end
end

r = rowmax - 1;
for j=(col):-1:1
```

```
        if bw(r,j)~=0
            White_pix = [r,j]
            column = j
            break;
        end
end

hypotenuse = sqrt((r-row)^2+(column-col)^2);
adjacent = colmax-column;
thetad = acosd(adjacent/hypotenuse);
 theta = acos(adjacent/hypotenuse);

% Performs affine rotation
A2 = [cos(theta) sin(theta) 0; -sin(theta) cos(theta) 0; 0 0 1];
tform2 = maketform('affine', A2);
new = imtransform(bw2,tform2);

% Crop image process begins
[rows columns numberOfColorBands] = size(new)
% Enlarges figure to full screen
set(gcf, 'units','normalized','outerposition',[0 0 1 1]);
% Gets all rows and columns where the image is nonzero
[nonZeroRows nonZeroColumns] = find(new);
% Gets the cropping parameters
topRow = min(nonZeroRows(:));
bottomRow = max(nonZeroRows(:));
 leftColumn = min(nonZeroColumns(:));
rightColumn = max(nonZeroColumns(:));
% Extracts a cropped image from the original.
croppedImage = new(topRow:bottomRow, leftColumn:rightColumn);

% Saves the normalized image
imwrite(croppedImage, '120_10_01_reg1.tif');
```

2. Matlab script for applying the gradientfaces normalization technique

```
% Writes in image (e.g. image '120_10_01_reg1.tif')
X = imread('120_10_01_reg1.tif');
% Performs Gradientfaces normalization
Y = gradientfaces(X);
mx = max(Y(:));
mn = min(Y(:));
imgScaled = (Y-mn)/(mx-mn);

% Saves image
imwrite(uint8(round(imgScaled*255)), '120_10_01_reg4.tif');
```

3. Matlab script for applying the homomorphic-filtering-based normalization technique

```
% Writes in image (e.g. image '120_10_01_reg1.tif')
X = imread('120_10_01_reg1.tif');

% Performs homomorphic-filtering-based normalization
Y = normalize8(homomorphic(X, 2, .25, 2));

% Saves image
imwrite(uint8(Y), '120_10_01_reg2.tif');
```

4. Matlab script for applying the Tan and Triggs normalization technique

```
% Writes in image (e.g. image '120_10_01_reg1.tif')
X = imread('120_10_01_reg1.tif');

% Performs Tans and Triggs normalization
Y = tantriggs(X);
mx = max(Y(:));
mn = min(Y(:));
imgScaled = (Y-mn)/(mx-mn);

% Saves image
imwrite(uint8(round(imgScaled*255)), '120_10_01_reg5.tif');
```

5. Matlab script for applying the wavelet-based normalization technique

```
% Writes in image (e.g. image ‘120_10_01_reg1.tif’)
X = imread(‘120_10_01_reg1.tif’);

% Performs wavelet-based normalization
Y=wavelet_normalization(X,1.4,'db1');
mx = max(Y(:));
mn = min(Y(:));
imgScaled = (Y-mn)/(mx-mn);

% Saves image
imwrite(uint8(round(imgScaled*255)), ‘120_10_01_reg3.tif’);
```

6. Matlab script for calculating the gray-level co-occurrence matrix (GLCM)

```
% Import image data into ‘data’ (e.g. image ‘120_10_01_reg3.tif’)
data = importdata(‘120_10_01_reg3.tif’);

% Creates GLCM from image ‘data’
GLCM2 = graycomatrix(data, 'offset', [0 1], 'Symmetric', true);

% Calculates statistics: contrast, correlation, energy, and homogeneity
stats = graycoprops(GLCM2,{'contrast', 'correlation', 'energy', 'homogeneity'});

% Converts structure to array
x = struct2array(stats);

% Evaluates each statistical property to the appropriate variable
eval(‘con120_10_01_reg3 = x(1);');
eval('corr120_10_01_reg3 = x(2);');
eval('ener120_10_01_reg3 = x(3);');
eval('homo120_10_01_reg3 = x(4);');
```

Appendix B – Representative GLCM Results Data

GLCM data were obtained from Olympus CX31 compound microscope, 40x objective, montaged Shaft 2 of Individual #30.

Individual	Hair	Normalized, Non-Filtered			
		Contrast	Correlation	Energy	Homogeneity
30	1	0.05207771	0.987543092	0.384483853	0.98097433
	2	0.045949572	0.989445523	0.421299301	0.983397707
	3	0.038411666	0.990726355	0.268128274	0.985259879
	4	0.040887461	0.992089623	0.271272013	0.984058971
	5	0.055215712	0.988657868	0.373677686	0.978950053
	6	0.051945246	0.989518296	0.296625818	0.979207665
	7	0.042353396	0.993374047	0.298439643	0.984275331
	8	0.049216657	0.990051427	0.385395407	0.980978393
	9	0.040320783	0.988331367	0.285384489	0.982229431
	10	0.035212496	0.988991969	0.333006736	0.985882417

Individual	Hair	Gradient Face Normalized Filter			
		Contrast	Correlation	Energy	Homogeneity
30	1	1.50476519	0.82908688	0.077493928	0.82631379
	2	1.529730949	0.826153486	0.076440316	0.81949939
	3	1.875751165	0.784940078	0.066714598	0.786981069
	4	1.733037953	0.794167684	0.074654283	0.804807183
	5	1.500936162	0.828947443	0.078062495	0.832457966
	6	1.348174555	0.843932618	0.082613171	0.842371591
	7	1.633234964	0.808920914	0.075230284	0.811953221
	8	1.541306633	0.822828589	0.07739231	0.830439335
	9	1.816810764	0.784687073	0.075237636	0.806769866
	10	1.990035864	0.772351092	0.065145299	0.780215509

Individual	Hair	Homomorphic Normalized Filter			
		Contrast	Correlation	Energy	Homogeneity
30	1	0.031189726	0.978426659	0.822170521	0.995737118
	2	0.029491391	0.979114072	0.814998185	0.995100673
	3	0.035827112	0.980005031	0.671840453	0.991061447
	4	0.035647192	0.982673953	0.403861112	0.987846008
	5	0.043287448	0.974313991	0.538227116	0.985109187
	6	0.039662856	0.978959707	0.644774439	0.988755167
	7	0.022484164	0.987908651	0.732095907	0.995511898
	8	0.05281285	0.966905268	0.378754472	0.978783467
	9	0.021447002	0.982174724	0.626724352	0.992520424
	10	0.03821177	0.980562519	0.694149891	0.991325953

Individual	Hair	Tan and Triggs Normalized Filter			
		Contrast	Correlation	Energy	Homogeneity
30	1	0.278437504	0.926563443	0.142558519	0.883142863
	2	0.304732469	0.917385402	0.134895423	0.871269329
	3	0.461825851	0.899258138	0.092058046	0.814620684
	4	0.580017999	0.917766	0.069993145	0.794198378
	5	0.316725853	0.929587888	0.120660473	0.867865907
	6	0.301143333	0.93529588	0.11651653	0.870078652
	7	0.435468431	0.921845639	0.08761693	0.825946262
	8	0.350567794	0.928836068	0.105189123	0.85298599
	9	0.60889506	0.924263429	0.069265462	0.79500749
	10	0.488511836	0.901685328	0.086657219	0.808503536

Individual	Hair	Wavelet Normalized Filter			
		Contrast	Correlation	Energy	Homogeneity
30	1	0.197766413	0.98318633	0.103246588	0.929512764
	2	0.168528232	0.985840895	0.105009008	0.93904032
	3	0.135706124	0.988722027	0.112698838	0.952847688
	4	0.141147607	0.9883788	0.115475729	0.948969149
	5	0.20063323	0.983166612	0.101499243	0.924084453
	6	0.166393599	0.986120197	0.106874713	0.935982448
	7	0.142657664	0.988228301	0.112989268	0.94724625
	8	0.18966628	0.984022621	0.103022781	0.926514445
	9	0.153537289	0.987286123	0.113788916	0.937822071
	10	0.157833991	0.986805311	0.108747489	0.943968536

Appendix C – ANOVA Result Tables

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.61204877	119	0.00514327	1.72585463	0.00153926	1.35259934
Within Groups	0.35761531	120	0.00298013			
Total	0.96966408	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.01462966	119	0.00012294	3.05877445	1.3051E-09	1.35259934
Within Groups	0.00482304	120	4.0192E-05			
Total	0.0194527	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.84988293	119	0.00714187	2.36116158	1.9192E-06	1.35259934
Within Groups	0.36296745	120	0.00302473			
Total	1.21285038	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00507286	119	4.2629E-05	1.44505559	0.02258056	1.35259934
Within Groups	0.00353999	120	2.95E-05			
Total	0.00861285	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.11142669	119	0.00933972	1.27010029	0.09628137	1.35259934
Within Groups	0.88242355	120	0.00735353			
Total	1.99385024	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.01530669	119	0.00012863	2.38720581	1.4538E-06	1.35259934
Within Groups	0.00646585	120	5.3882E-05			
Total	0.02177253	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.87503998	119	0.00735328	1.79288124	0.00077876	1.35259934
Within Groups	0.49216492	120	0.00410137			
Total	1.3672049	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 –Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00626283	119	5.2629E-05	0.8584493	0.79722086	1.35259934
Within Groups	0.00735682	120	6.1307E-05			
Total	0.01361964	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.68977557	119	0.00579643	1.3174512	0.06655755	1.35259934
Within Groups	0.52796795	120	0.00439973			
Total	1.21774352	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01523092	119	0.00012799	3.23112954	2.3026E-10	1.35259934
Within Groups	0.00475342	120	3.9612E-05			
Total	0.01998433	239				

Leica DM1000 – 10x – Montaged –2 Hairs – No Filter – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.99127913	119	0.00833008	2.61015024	1.365E-07	1.35259934
Within Groups	0.38296999	120	0.00319142			
Total	1.37424912	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00531615	119	4.4674E-05	0.92480786	0.66495643	1.35259934
Within Groups	0.00579669	120	4.8306E-05			
Total	0.01111284	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	36.9332003	119	0.31036303	2.31491196	3.1438E-06	1.35259934
Within Groups	16.0885442	120	0.1340712			
Total	53.0217445	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.32479746	119	0.00272939	2.66791511	7.4303E-08	1.35259934
Within Groups	0.1227651	120	0.00102304			
Total	0.44756256	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.30886001	119	0.00259546	1.33923873	0.05580672	1.35259934
Within Groups	0.23256157	120	0.00193801			
Total	0.54142158	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.22150298	119	0.00186137	1.87578487	0.00033079	1.35259934
Within Groups	0.11907781	120	0.00099232			
Total	0.34058079	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	48.8494217	119	0.41049934	3.03256172	1.7037E-09	1.35259934
Within Groups	16.2436664	120	0.13536389			
Total	65.0930882	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.46745459	119	0.00392819	4.14143509	4.1705E-14	1.35259934
Within Groups	0.11382112	120	0.00094851			
Total	0.58127571	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.22992182	119	0.00193212	2.82889047	1.383E-08	1.35259934
Within Groups	0.08195932	120	0.00068299			
Total	0.31188113	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.29205693	119	0.00245426	3.00135859	2.342E-09	1.35259934
Within Groups	0.09812596	120	0.00081772			
Total	0.39018289	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	58.272374	119	0.48968382	2.03306589	6.3348E-05	1.35259934
Within Groups	28.9031743	120	0.24085979			
Total	87.1755483	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.53641666	119	0.0045077	2.57500261	1.9785E-07	1.35259934
Within Groups	0.2100675	120	0.00175056			
Total	0.74648417	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.38839162	119	0.0032638	1.42747702	0.02637879	1.35259934
Within Groups	0.27436898	120	0.00228641			
Total	0.66276061	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces– Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.35259717	119	0.002963	2.00157119	8.8396E-05	1.35259934
Within Groups	0.17764053	120	0.00148034			
Total	0.5302377	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.10265403	119	0.00086264	1.13948708	0.23814413	1.35259934
Within Groups	0.09084497	120	0.00075704			
Total	0.193499	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05287728	119	0.00044435	1.4275533	0.02636111	1.35259934
Within Groups	0.03735176	120	0.00031126			
Total	0.09022903	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.10684312	119	0.0093012	1.36207605	0.04621356	1.35259934
Within Groups	0.81944347	120	0.0068287			
Total	1.92628659	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00396296	119	3.3302E-05	0.8283679	0.84752921	1.35259934
Within Groups	0.00482426	120	4.0202E-05			
Total	0.00878722	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.20332664	119	0.00170863	1.06962731	0.35667123	1.35259934
Within Groups	0.19168851	120	0.0015974			
Total	0.39501516	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.09561639	119	0.0008035	1.37048783	0.04306965	1.35259934
Within Groups	0.07035443	120	0.00058629			
Total	0.16597082	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.30618316	119	0.01097633	1.52700876	0.01068764	1.35259934
Within Groups	0.86257494	120	0.00718812			
Total	2.1687581	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00792057	119	6.6559E-05	1.09386029	0.31223374	1.35259934
Within Groups	0.00730179	120	6.0848E-05			
Total	0.01522236	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.12822529	119	0.00107752	1.22844729	0.13100247	1.35259934
Within Groups	0.10525711	120	0.00087714			
Total	0.23348241	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.06287579	119	0.00052837	1.51786473	0.01163824	1.35259934
Within Groups	0.04177194	120	0.0003481			
Total	0.10464773	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.42640122	119	0.01198656	1.22047969	0.13868335	1.35259934
Within Groups	1.17854299	120	0.00982119			
Total	2.60494421	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00617306	119	5.1874E-05	0.97086962	0.56394747	1.35259934
Within Groups	0.00641171	120	5.3431E-05			
Total	0.01258477	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	182.104863	119	1.53029296	1.29289819	0.08079657	1.35259934
Within Groups	142.033732	120	1.18361443			
Total	324.138595	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.42308603	119	0.00355534	1.47712742	0.01692375	1.35259934
Within Groups	0.28883181	120	0.00240693			
Total	0.71191784	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.73132271	119	0.00614557	1.37318969	0.04210135	1.35259934
Within Groups	0.53704764	120	0.0044754			
Total	1.26837035	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.43509009	119	0.00365622	1.58283158	0.00629954	1.35259934
Within Groups	0.27719077	120	0.00230992			
Total	0.71228086	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	190.543754	119	1.60120801	2.0402885	5.8681E-05	1.35259934
Within Groups	94.1753881	120	0.7847949			
Total	284.719142	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.40319595	119	0.0033882	2.23303888	7.5353E-06	1.35259934
Within Groups	0.18207661	120	0.00151731			
Total	0.58527256	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.5178819	119	0.00435195	1.58368476	0.00624819	1.35259934
Within Groups	0.32975871	120	0.00274799			
Total	0.84764061	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.31722674	119	0.00266577	1.34747758	0.05215933	1.35259934
Within Groups	0.23740099	120	0.00197834			
Total	0.55462774	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	217.119709	119	1.82453537	1.33665148	0.05699773	1.35259934
Within Groups	163.800547	120	1.36500456			
Total	380.920257	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.51215675	119	0.00430384	1.49138092	0.0148605	1.35259934
Within Groups	0.3462969	120	0.00288581			
Total	0.85845365	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.68720667	119	0.00577485	1.15892134	0.21057363	1.35259934
Within Groups	0.59795388	120	0.00498295			
Total	1.28516055	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.41820569	119	0.00351433	1.50088653	0.01361808	1.35259934
Within Groups	0.28098062	120	0.00234151			
Total	0.69918631	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.70436003	119	0.02272571	1.97246267	0.00012017	1.35259934
Within Groups	1.38257914	120	0.01152149			
Total	4.08693917	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.08415275	119	0.00070717	2.16233805	1.6024E-05	1.35259934
Within Groups	0.03924452	120	0.00032704			
Total	0.12339727	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.37145188	119	0.00312144	1.45360692	0.02092163	1.35259934
Within Groups	0.25768543	120	0.00214738			
Total	0.62913731	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.01465401	119	0.00012314	3.06827697	1.1851E-09	1.35259934
Within Groups	0.00481611	120	4.0134E-05			
Total	0.01947012	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.76772291	119	0.03166154	1.38047492	0.03958726	1.35259934
Within Groups	2.75222998	120	0.02293525			
Total	6.51995289	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.18455859	119	0.00155091	1.15436772	0.21681852	1.35259934
Within Groups	0.16122203	120	0.00134352			
Total	0.34578062	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.27085608	119	0.0022761	2.63425351	1.0588E-07	1.35259934
Within Groups	0.10368485	120	0.00086404			
Total	0.37454094	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.01333906	119	0.00011209	1.88182628	0.00031063	1.35259934
Within Groups	0.00714792	120	5.9566E-05			
Total	0.02048698	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.48866694	119	0.02091317	1.53010891	0.01038235	1.35259934
Within Groups	1.64013169	120	0.01366776			
Total	4.12879864	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.09436324	119	0.00079297	1.27314174	0.09408057	1.35259934
Within Groups	0.07474126	120	0.00062284			
Total	0.1691045	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 –Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.43316872	119	0.00364007	1.39808383	0.03406097	1.35259934
Within Groups	0.31243391	120	0.00260362			
Total	0.74560263	239				

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.01319826	119	0.00011091	1.4313586	0.02549275	1.35259934
Within Groups	0.00929828	120	7.7486E-05			
Total	0.02249653	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.41082437	119	0.00345231	4.66392787	4.4812E-16	1.35259934
Within Groups	0.0888257	120	0.00074021			
Total	0.49965007	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.20111033	119	0.00169	12.3282937	1.9283E-35	1.35259934
Within Groups	0.01644999	120	0.00013708			
Total	0.21756032	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.22043776	119	0.01025578	5.82810195	4.8297E-20	1.35259934
Within Groups	0.21116541	120	0.00175971			
Total	1.43160317	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01346921	119	0.00011319	3.32112803	9.4259E-11	1.35259934
Within Groups	0.00408969	120	3.4081E-05			
Total	0.01755891	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.43600961	119	0.00366395	3.09463266	9.0735E-10	1.35259934
Within Groups	0.14207617	120	0.00118397			
Total	0.57808578	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.17145803	119	0.00144082	12.6362464	5.4486E-36	1.35259934
Within Groups	0.01368277	120	0.00011402			
Total	0.1851408	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.41537728	119	0.01189393	4.92401918	5.2122E-17	1.35259934
Within Groups	0.28985899	120	0.00241549			
Total	1.70523626	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0114474	119	9.6197E-05	2.98510006	2.7654E-09	1.35259934
Within Groups	0.00386707	120	3.2226E-05			
Total	0.01531447	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.64393426	119	0.00541121	2.39911992	1.2805E-06	1.35259934
Within Groups	0.27065987	120	0.0022555			
Total	0.91459413	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.22646702	119	0.00190308	14.0143918	2.5751E-38	1.35259934
Within Groups	0.0162954	120	0.00013579			
Total	0.24276242	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.3193159	119	0.01108669	4.92409353	5.209E-17	1.35259934
Within Groups	0.27018223	120	0.00225152			
Total	1.58949814	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01341455	119	0.00011273	2.84251226	1.2008E-08	1.35259934
Within Groups	0.00475892	120	3.9658E-05			
Total	0.01817347	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	26.3350032	119	0.22130255	3.32639019	8.9488E-11	1.35259934
Within Groups	7.98352095	120	0.06652934			
Total	34.3185242	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.22708517	119	0.00190828	5.75732954	8.1303E-20	1.35259934
Within Groups	0.03977425	120	0.00033145			
Total	0.26685941	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.22292299	119	0.0018733	1.73810736	0.00136015	1.35259934
Within Groups	0.12933395	120	0.00107778			
Total	0.35225694	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.15083267	119	0.0012675	2.32065533	2.9568E-06	1.35259934
Within Groups	0.0655419	120	0.00054618			
Total	0.21637457	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	22.7048697	119	0.19079722	2.98026507	2.9057E-09	1.35259934
Within Groups	7.68242634	120	0.06402022			
Total	30.387296	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.20124995	119	0.00169118	4.13778016	4.3093E-14	1.35259934
Within Groups	0.04904589	120	0.00040872			
Total	0.25029585	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.08560772	119	0.00071939	1.550201	0.00859498	1.35259934
Within Groups	0.05568769	120	0.00046406			
Total	0.14129541	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.12525997	119	0.0010526	2.43953621	8.3264E-07	1.35259934
Within Groups	0.05177729	120	0.00043148			
Total	0.17703726	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	34.3699235	119	0.28882289	2.36200798	1.9019E-06	1.35259934
Within Groups	14.6734247	120	0.12227854			
Total	49.0433482	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.25160195	119	0.0021143	3.26293013	1.6777E-10	1.35259934
Within Groups	0.07775718	120	0.00064798			
Total	0.32935913	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.23121277	119	0.00194296	1.3332883	0.05857943	1.35259934
Within Groups	0.17487271	120	0.00145727			
Total	0.40608547	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.20922887	119	0.00175823	1.98271591	0.00010786	1.35259934
Within Groups	0.10641317	120	0.00088678			
Total	0.31564204	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.12940252	119	0.00108742	1.46453729	0.01896557	1.35259934
Within Groups	0.08909977	120	0.0007425			
Total	0.21850229	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.11837303	119	0.00099473	3.38556392	5.0001E-11	1.35259934
Within Groups	0.03525787	120	0.00029382			
Total	0.1536309	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.96778813	119	0.00813267	1.97069156	0.00012243	1.35259934
Within Groups	0.49521743	120	0.00412681			
Total	1.46300555	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01303546	119	0.00010954	2.23859437	7.1013E-06	1.35259934
Within Groups	0.00587199	120	4.8933E-05			
Total	0.01890745	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.12507393	119	0.00105104	1.60739254	0.00497123	1.35259934
Within Groups	0.07846557	120	0.00065388			
Total	0.2035395	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.1452602	119	0.00122067	3.37455157	5.5705E-11	1.35259934
Within Groups	0.04340751	120	0.00036173			
Total	0.18866771	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.1643661	119	0.00978459	1.33751477	0.05659786	1.35259934
Within Groups	0.87785998	120	0.0073155			
Total	2.04222608	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0167801	119	0.00014101	1.90632183	0.00024058	1.35259934
Within Groups	0.00887631	120	7.3969E-05			
Total	0.02565642	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.15635183	119	0.00131388	1.21139693	0.14787359	1.35259934
Within Groups	0.13015198	120	0.0010846			
Total	0.28650381	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.16353092	119	0.00137421	2.72241467	4.1955E-08	1.35259934
Within Groups	0.06057311	120	0.00050478			
Total	0.22410403	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.02222841	119	0.00859015	1.37884597	0.04013735	1.35259934
Within Groups	0.74759516	120	0.00622996			
Total	1.76982357	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01281989	119	0.00010773	1.4424158	0.02311674	1.35259934
Within Groups	0.00896248	120	7.4687E-05			
Total	0.02178236	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	123.106076	119	1.03450484	1.95552636	0.00014362	1.35259934
Within Groups	63.4819267	120	0.52901606			
Total	186.588003	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.28117402	119	0.00236281	2.44584191	7.7861E-07	1.35259934
Within Groups	0.11592606	120	0.00096605			
Total	0.39710008	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.50735629	119	0.0042635	1.62424321	0.00421999	1.35259934
Within Groups	0.31498965	120	0.00262491			
Total	0.82234594	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.32780217	119	0.00275464	1.72566295	0.00154224	1.35259934
Within Groups	0.19155352	120	0.00159628			
Total	0.51935568	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	37.8241686	119	0.31785016	1.69115317	0.00218012	1.35259934
Within Groups	22.5538523	120	0.18794877			
Total	60.3780209	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.10033069	119	0.00084312	2.10631711	2.9103E-05	1.35259934
Within Groups	0.04803351	120	0.00040028			
Total	0.1483642	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.30010672	119	0.00252191	1.08842681	0.32190524	1.35259934
Within Groups	0.27804224	120	0.00231702			
Total	0.57814897	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.26813356	119	0.00225322	1.69549806	0.00208755	1.35259934
Within Groups	0.15947336	120	0.00132894			
Total	0.42760692	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	52.7954756	119	0.44365946	1.06253527	0.37028747	1.35259934
Within Groups	50.1057579	120	0.41754798			
Total	102.901233	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.10817729	119	0.00090905	1.08329795	0.33119235	1.35259934
Within Groups	0.10069838	120	0.00083915			
Total	0.20887567	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.44448182	119	0.00373514	1.50137003	0.01355757	1.35259934
Within Groups	0.29853864	120	0.00248782			
Total	0.74302045	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.25693636	119	0.00215913	1.51199162	0.01229025	1.35259934
Within Groups	0.1713604	120	0.001428			
Total	0.42829676	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.49098481	119	0.02933601	5.65324544	1.7622E-19	1.35259934
Within Groups	0.62270794	120	0.00518923			
Total	4.11369275	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05134937	119	0.00043151	3.39155608	4.7149E-11	1.35259934
Within Groups	0.01526759	120	0.00012723			
Total	0.06661695	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.30173769	119	0.00253561	1.72224237	0.00159631	1.35259934
Within Groups	0.17667275	120	0.00147227			
Total	0.47841044	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.25089443	119	0.00210836	9.98127152	7.7616E-31	1.35259934
Within Groups	0.02534775	120	0.00021123			
Total	0.27624218	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.42919389	119	0.02881676	4.62941233	5.9925E-16	1.35259934
Within Groups	0.74696536	120	0.00622471			
Total	4.17615925	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05571018	119	0.00046815	2.62211897	1.2032E-07	1.35259934
Within Groups	0.02142478	120	0.00017854			
Total	0.07713497	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.17092727	119	0.00143636	1.95448519	0.0001452	1.35259934
Within Groups	0.08818876	120	0.00073491			
Total	0.25911604	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.29677982	119	0.00249395	13.3706673	2.9618E-37	1.35259934
Within Groups	0.02238286	120	0.00018652			
Total	0.31916268	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.54599225	119	0.02979825	3.89006432	4.1034E-13	1.35259934
Within Groups	0.91921115	120	0.00766009			
Total	4.4652034	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.09429504	119	0.0007924	1.71259743	0.0017589	1.35259934
Within Groups	0.05552235	120	0.00046269			
Total	0.14981739	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.38620146	119	0.00324539	1.57237664	0.00696243	1.35259934
Within Groups	0.24768039	120	0.002064			
Total	0.63388185	239				

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.27351831	119	0.00229847	12.6862859	4.448E-36	1.35259934
Within Groups	0.02174133	120	0.00018118			
Total	0.29525964	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01234296	119	0.00010372	2.55159591	2.5344E-07	1.35259934
Within Groups	0.004878	120	4.065E-05			
Total	0.01722096	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03726087	119	0.00031312	4.45131115	2.7378E-15	1.35259934
Within Groups	0.00844111	120	7.0343E-05			
Total	0.04570197	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.86216922	119	0.01564848	4.67209575	4.1841E-16	1.35259934
Within Groups	0.40192192	120	0.00334935			
Total	2.26409114	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00178411	119	1.4993E-05	3.9918108	1.6127E-13	1.35259934
Within Groups	0.0004507	120	3.7558E-06			
Total	0.00223481	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01507309	119	0.00012666	2.78615726	2.1565E-08	1.35259934
Within Groups	0.00545545	120	4.5462E-05			
Total	0.02052854	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05176818	119	0.00043503	4.4334906	3.1931E-15	1.35259934
Within Groups	0.01177474	120	9.8123E-05			
Total	0.06354292	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.55217818	119	0.01304351	3.94646906	2.4416E-13	1.35259934
Within Groups	0.39661319	120	0.00330511			
Total	1.94879137	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00229746	119	1.9306E-05	3.29843005	1.1798E-10	1.35259934
Within Groups	0.00070238	120	5.8532E-06			
Total	0.00299984	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0131948	119	0.00011088	1.80381807	0.00069613	1.35259934
Within Groups	0.0073764	120	6.147E-05			
Total	0.02057119	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03807048	119	0.00031992	6.81337637	5.1437E-23	1.35259934
Within Groups	0.00563456	120	4.6955E-05			
Total	0.04370505	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.24808163	119	0.01889144	4.94256782	4.4822E-17	1.35259934
Within Groups	0.45866302	120	0.00382219			
Total	2.70674465	239				

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00172776	119	1.4519E-05	1.87414263	0.00033649	1.35259934
Within Groups	0.00092964	120	7.747E-06			
Total	0.00265739	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	52.8735397	119	0.44431546	6.41549885	7.4776E-22	1.35259934
Within Groups	8.31078868	120	0.06925657			
Total	61.1843284	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.53181344	119	0.00446902	7.75549299	1.3812E-25	1.35259934
Within Groups	0.06914873	120	0.00057624			
Total	0.60096217	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01718131	119	0.00014438	2.5317276	3.1279E-07	1.35259934
Within Groups	0.00684343	120	5.7029E-05			
Total	0.02402474	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.1609513	119	0.00135253	5.0754719	1.5354E-17	1.35259934
Within Groups	0.03197808	120	0.00026648			
Total	0.19292938	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	61.1281394	119	0.51368184	7.69800724	1.9516E-25	1.35259934
Within Groups	8.00750367	120	0.0667292			
Total	69.1356431	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.58986669	119	0.00495686	9.26917332	2.8887E-29	1.35259934
Within Groups	0.06417223	120	0.00053477			
Total	0.65403892	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01876111	119	0.00015766	2.30464602	3.5079E-06	1.35259934
Within Groups	0.00820897	120	6.8408E-05			
Total	0.02697008	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.1839282	119	0.00154562	5.93899897	2.1533E-20	1.35259934
Within Groups	0.03122981	120	0.00026025			
Total	0.21515801	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	72.0445764	119	0.60541661	5.48587287	6.2338E-19	1.35259934
Within Groups	13.2431055	120	0.11035921			
Total	85.2876819	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.69171602	119	0.00581274	6.64320944	1.594E-22	1.35259934
Within Groups	0.10499876	120	0.00087499			
Total	0.79671478	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02957875	119	0.00024856	1.53239535	0.01016249	1.35259934
Within Groups	0.0194645	120	0.0001622			
Total	0.04904325	239				

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.22020837	119	0.00185049	4.10163563	5.9618E-14	1.35259934
Within Groups	0.0541391	120	0.00045116			
Total	0.27434747	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03406746	119	0.00028628	2.62232483	1.2006E-07	1.35259934
Within Groups	0.01310049	120	0.00010917			
Total	0.04716795	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03824469	119	0.00032138	2.97074392	3.2032E-09	1.35259934
Within Groups	0.01298196	120	0.00010818			
Total	0.05122665	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.75717698	119	0.02316955	6.10357911	6.6132E-21	1.35259934
Within Groups	0.45552724	120	0.00379606			
Total	3.21270422	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0068905	119	5.7903E-05	2.97513482	3.0624E-09	1.35259934
Within Groups	0.00233549	120	1.9462E-05			
Total	0.00922599	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03281521	119	0.00027576	1.31002647	0.07061378	1.35259934
Within Groups	0.02525977	120	0.0002105			
Total	0.05807497	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0408792	119	0.00034352	2.70573392	4.9963E-08	1.35259934
Within Groups	0.01523532	120	0.00012696			
Total	0.05611451	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.6038879	119	0.02188141	3.08729	9.7735E-10	1.35259934
Within Groups	0.85050945	120	0.00708758			
Total	3.45439734	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00679696	119	5.7117E-05	1.55654296	0.00809428	1.35259934
Within Groups	0.0044034	120	3.6695E-05			
Total	0.01120036	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02976545	119	0.00025013	1.15296142	0.21877369	1.35259934
Within Groups	0.02603347	120	0.00021695			
Total	0.05579892	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.04123271	119	0.00034649	3.46856335	2.2247E-11	1.35259934
Within Groups	0.01198744	120	9.9895E-05			
Total	0.05322016	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.96710185	119	0.02493363	4.09117917	6.5505E-14	1.35259934
Within Groups	0.73133817	120	0.00609448			
Total	3.69844002	239				

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00603086	119	5.068E-05	1.30233165	0.07504223	1.35259934
Within Groups	0.00466973	120	3.8914E-05			
Total	0.0107006	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	92.8933449	119	0.78061634	1.4680881	0.01836763	1.35259934
Within Groups	63.8067708	120	0.53172309			
Total	156.700116	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.11468968	119	0.00096378	2.78793795	2.1169E-08	1.35259934
Within Groups	0.04148351	120	0.0003457			
Total	0.1561732	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02940184	119	0.00024707	2.95684572	3.6937E-09	1.35259934
Within Groups	0.01002721	120	8.356E-05			
Total	0.03942905	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.10853451	119	0.00091205	3.25587114	1.7997E-10	1.35259934
Within Groups	0.03361514	120	0.00028013			
Total	0.14214965	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	75.8025026	119	0.63699582	1.37930589	0.03998135	1.35259934
Within Groups	55.4188154	120	0.46182346			
Total	131.221318	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.09738316	119	0.00081835	2.59658323	1.5751E-07	1.35259934
Within Groups	0.03781951	120	0.00031516			
Total	0.13520267	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02287235	119	0.0001922	1.06869196	0.35845187	1.35259934
Within Groups	0.02158204	120	0.00017985			
Total	0.04445439	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.10547445	119	0.00088634	1.85622939	0.00040529	1.35259934
Within Groups	0.05729938	120	0.00047749			
Total	0.16277383	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	91.0437563	119	0.76507358	1.12960686	0.25308139	1.35259934
Within Groups	81.2750282	120	0.6772919			
Total	172.318784	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.13234085	119	0.00111211	1.6045926	0.00510788	1.35259934
Within Groups	0.08316937	120	0.00069308			
Total	0.21551022	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.06587823	119	0.0005536	1.12880557	0.25431998	1.35259934
Within Groups	0.05885144	120	0.00049043			
Total	0.12472967	239				

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.14543303	119	0.00122213	1.33965977	0.05561499	1.35259934
Within Groups	0.10947194	120	0.00091227			
Total	0.25490498	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.20764989	119	0.00174496	1.96450059	0.00013068	1.35259934
Within Groups	0.10658936	120	0.00088824			
Total	0.31423925	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00130128	119	1.0935E-05	1.88601366	0.00029737	1.35259934
Within Groups	0.00069576	120	5.798E-06			
Total	0.00199705	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01767636	119	0.00014854	2.10215489	3.0421E-05	1.35259934
Within Groups	0.00847935	120	7.0661E-05			
Total	0.02615571	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02895535	119	0.00024332	2.80007493	1.8657E-08	1.35259934
Within Groups	0.01042782	120	8.6898E-05			
Total	0.03938317	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.29959617	119	0.00251761	3.0790477	1.0625E-09	1.35259934
Within Groups	0.09811923	120	0.00081766			
Total	0.39771539	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00186486	119	1.5671E-05	3.12274093	6.8302E-10	1.35259934
Within Groups	0.00060221	120	5.0184E-06			
Total	0.00246707	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01872106	119	0.00015732	2.18208613	1.298E-05	1.35259934
Within Groups	0.00865153	120	7.2096E-05			
Total	0.02737259	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03698727	119	0.00031082	4.66697203	4.368E-16	1.35259934
Within Groups	0.00799192	120	6.6599E-05			
Total	0.04497919	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.52271049	119	0.00439253	2.71623761	4.4757E-08	1.35259934
Within Groups	0.1940563	120	0.00161714			
Total	0.71676679	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00348389	119	2.9276E-05	2.74349267	3.3655E-08	1.35259934
Within Groups	0.00128054	120	1.0671E-05			
Total	0.00476443	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02592271	119	0.00021784	1.2387692	0.12156658	1.35259934
Within Groups	0.02110203	120	0.00017585			
Total	0.04702475	239				

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.04832292	119	0.00040607	5.66641186	1.5971E-19	1.35259934
Within Groups	0.00859962	120	7.1664E-05			
Total	0.05692254	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01223796	119	0.00010284	1.73494785	0.00140429	1.35259934
Within Groups	0.00711307	120	5.9276E-05			
Total	0.01935103	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00865103	119	7.2698E-05	3.65233865	3.8061E-12	1.35259934
Within Groups	0.00238853	120	1.9904E-05			
Total	0.01103956	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.2237144	119	0.01028331	2.70968877	4.7935E-08	1.35259934
Within Groups	0.45540201	120	0.00379502			
Total	1.67911641	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0026032	119	2.1876E-05	1.98610663	0.00010407	1.35259934
Within Groups	0.00132172	120	1.1014E-05			
Total	0.00392492	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01702438	119	0.00014306	1.8059022	0.00068138	1.35259934
Within Groups	0.0095063	120	7.9219E-05			
Total	0.02653068	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00754446	119	6.3399E-05	3.61229326	5.5738E-12	1.35259934
Within Groups	0.0021061	120	1.7551E-05			
Total	0.00965057	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.4451098	119	0.01214378	1.86098449	0.00038578	1.35259934
Within Groups	0.7830552	120	0.00652546			
Total	2.228165	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00172143	119	1.4466E-05	1.05745043	0.38020947	1.35259934
Within Groups	0.00164159	120	1.368E-05			
Total	0.00336302	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03047438	119	0.00025609	1.1344208	0.24572606	1.35259934
Within Groups	0.02708913	120	0.00022574			
Total	0.05756351	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00857988	119	7.21E-05	4.89090491	6.8291E-17	1.35259934
Within Groups	0.00176899	120	1.4742E-05			
Total	0.01034888	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.77993053	119	0.0149574	1.96239086	0.00013362	1.35259934
Within Groups	0.91464344	120	0.00762203			
Total	2.69457397	239				

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00235811	119	1.9816E-05	1.5809406	0.0064148	1.35259934
Within Groups	0.00150412	120	1.2534E-05			
Total	0.00386223	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	40.2158747	119	0.33794853	3.13865303	5.818E-10	1.35259934
Within Groups	12.920773	120	0.10767311			
Total	53.1366476	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.34887955	119	0.00293176	5.41707795	1.0553E-18	1.35259934
Within Groups	0.06494485	120	0.00054121			
Total	0.41382439	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.42776555	119	0.00359467	1.9081802	0.00023595	1.35259934
Within Groups	0.22605843	120	0.00188382			
Total	0.65382397	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.24728076	119	0.00207799	2.51725635	3.6465E-07	1.35259934
Within Groups	0.09905974	120	0.0008255			
Total	0.3463405	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	63.4523577	119	0.53321309	4.51697271	1.5577E-15	1.35259934
Within Groups	14.1655872	120	0.11804656			
Total	77.6179449	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.48438725	119	0.00407048	5.89219788	3.0243E-20	1.35259934
Within Groups	0.08289907	120	0.00069083			
Total	0.56728632	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.23684812	119	0.00199032	1.79815899	0.00073775	1.35259934
Within Groups	0.13282387	120	0.00110687			
Total	0.36967199	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.34883039	119	0.00293135	3.78113694	1.1297E-12	1.35259934
Within Groups	0.09303068	120	0.00077526			
Total	0.44186106	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	62.5253629	119	0.52542322	2.18179141	1.3021E-05	1.35259934
Within Groups	28.8986315	120	0.24082193			
Total	91.4239945	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.47445177	119	0.00398699	3.75852575	1.3963E-12	1.35259934
Within Groups	0.12729426	120	0.00106079			
Total	0.60174603	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.62567337	119	0.00525776	1.55011112	0.00860229	1.35259934
Within Groups	0.40702316	120	0.00339186			
Total	1.03269654	239				

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.37403194	119	0.00314313	1.93806516	0.00017254	1.35259934
Within Groups	0.19461423	120	0.00162179			
Total	0.56864617	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05725966	119	0.00048117	1.33697289	0.05684856	1.35259934
Within Groups	0.04318773	120	0.0003599			
Total	0.10044739	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02213941	119	0.00018605	1.97775247	0.00011366	1.35259934
Within Groups	0.0112883	120	9.4069E-05			
Total	0.03342771	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.33918776	119	0.01965704	1.64889924	0.00331423	1.35259934
Within Groups	1.43055727	120	0.01192131			
Total	3.76974503	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00596107	119	5.0093E-05	1.18013111	0.18320407	1.35259934
Within Groups	0.00509364	120	4.2447E-05			
Total	0.01105472	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.04188449	119	0.00035197	1.18885789	0.17275231	1.35259934
Within Groups	0.03552692	120	0.00029606			
Total	0.0774114	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01893798	119	0.00015914	1.82862331	0.00053925	1.35259934
Within Groups	0.01044344	120	8.7029E-05			
Total	0.02938142	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.5576718	119	0.02149304	1.89979449	0.00025756	1.35259934
Within Groups	1.35760202	120	0.01131335			
Total	3.91527382	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00547231	119	4.5986E-05	0.90752561	0.70154807	1.35259934
Within Groups	0.00608059	120	5.0672E-05			
Total	0.0115529	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05475621	119	0.00046014	1.34948204	0.05130458	1.35259934
Within Groups	0.0409167	120	0.00034097			
Total	0.09567291	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02147279	119	0.00018044	1.82550693	0.00055687	1.35259934
Within Groups	0.01186149	120	9.8846E-05			
Total	0.03333429	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.20612378	119	0.01853886	1.65891858	0.00300248	1.35259934
Within Groups	1.34103183	120	0.01117527			
Total	3.54715561	239				

Olympus – 10x – Montaged – 2 Hairs – Homomorphic– Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0076387	119	6.4191E-05	1.48966927	0.0150952	1.35259934
Within Groups	0.00517087	120	4.3091E-05			
Total	0.01280957	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	378.638258	119	3.1818341	1.62393527	0.00423268	1.35259934
Within Groups	235.120265	120	1.95933554			
Total	613.758523	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.81556661	119	0.0068535	1.87019866	0.00035057	1.35259934
Within Groups	0.43975013	120	0.00366458			
Total	1.25531674	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.02076522	119	0.00857786	1.84571264	0.00045195	1.35259934
Within Groups	0.55769412	120	0.00464745			
Total	1.57845933	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.58427111	119	0.00490984	1.75527975	0.00114288	1.35259934
Within Groups	0.33566214	120	0.00279718			
Total	0.91993325	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	244.202323	119	2.05212036	1.38526835	0.03800777	1.35259934
Within Groups	177.766599	120	1.48138833			
Total	421.968923	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.40538065	119	0.00340656	1.26224247	0.10216854	1.35259934
Within Groups	0.32385791	120	0.00269882			
Total	0.72923856	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.59134535	119	0.00496929	1.29769406	0.07782543	1.35259934
Within Groups	0.45951866	120	0.00382932			
Total	1.050864	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.42188643	119	0.00354526	1.42424377	0.02713835	1.35259934
Within Groups	0.29870708	120	0.00248923			
Total	0.7205935	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	314.48015	119	2.64269034	1.24827305	0.11337621	1.35259934
Within Groups	254.049257	120	2.11707714			
Total	568.529407	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.68469536	119	0.00575374	1.48223595	0.0161553	1.35259934
Within Groups	0.46581592	120	0.0038818			
Total	1.15051128	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.07513226	119	0.00903472	1.5707434	0.00707181	1.35259934
Within Groups	0.69022539	120	0.00575188			
Total	1.76535765	239				

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.57716403	119	0.00485012	1.54751721	0.0088156	1.35259934
Within Groups	0.37609543	120	0.00313413			
Total	0.95325947	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.15885673	119	0.00133493	2.37687373	1.6231E-06	1.35259934
Within Groups	0.06739595	120	0.00056163			
Total	0.22625268	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00129364	119	1.0871E-05	2.2282606	7.9297E-06	1.35259934
Within Groups	0.00058544	120	4.8786E-06			
Total	0.00187907	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.45917379	119	0.0038586	1.8995742	0.00025815	1.35259934
Within Groups	0.24375589	120	0.0020313			
Total	0.70292968	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02591366	119	0.00021776	2.57846597	1.9074E-07	1.35259934
Within Groups	0.01013449	120	8.4454E-05			
Total	0.03604815	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.15599796	119	0.00131091	2.05818856	4.8535E-05	1.35259934
Within Groups	0.07643074	120	0.00063692			
Total	0.23242869	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00111853	119	9.3994E-06	2.01264823	7.8629E-05	1.35259934
Within Groups	0.00056042	120	4.6702E-06			
Total	0.00167895	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.22265754	119	0.00187107	1.64774762	0.003352	1.35259934
Within Groups	0.13626396	120	0.00113553			
Total	0.35892149	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02268339	119	0.00019062	3.08157344	1.0356E-09	1.35259934
Within Groups	0.00742283	120	6.1857E-05			
Total	0.03010622	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.23901181	119	0.0020085	1.17068649	0.19504435	1.35259934
Within Groups	0.20587947	120	0.00171566			
Total	0.44489128	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00213162	119	1.7913E-05	1.2028534	0.156951	1.35259934
Within Groups	0.00178703	120	1.4892E-05			
Total	0.00391865	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.62766457	119	0.00527449	1.56792747	0.00726425	1.35259934
Within Groups	0.40367879	120	0.00336399			
Total	1.03134336	239				

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02602086	119	0.00021866	3.27244525	1.5264E-10	1.35259934
Within Groups	0.00801832	120	6.6819E-05			
Total	0.03403919	239				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05681336	119	0.00047742	2.39672332	2.6593E-13	1.23820629
Within Groups	0.21513415	1080	0.0001992			
Total	0.2719475	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02141675	119	0.00017997	5.9082469	6.194E-60	1.23820629
Within Groups	0.03289817	1080	3.0461E-05			
Total	0.05431492	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.41915638	119	0.03713577	6.2469527	2.4746E-64	1.23820629
Within Groups	6.42019097	1080	0.00594462			
Total	10.8393474	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02007724	119	0.00016872	5.77980156	2.973E-58	1.23820629
Within Groups	0.03152593	1080	2.9191E-05			
Total	0.05160317	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.08402438	119	0.00070609	3.06304931	8.3854E-22	1.23820629
Within Groups	0.24895916	1080	0.00023052			
Total	0.33298353	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02714803	119	0.00022813	7.27280314	2.5177E-77	1.23820629
Within Groups	0.03387766	1080	3.1368E-05			
Total	0.06102569	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.30992006	119	0.04462118	5.90443515	6.9464E-60	1.23820629
Within Groups	8.16180887	1080	0.00755723			
Total	13.4717289	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01599019	119	0.00013437	4.02955201	8.5583E-35	1.23820629
Within Groups	0.0360142	1080	3.3346E-05			
Total	0.05200439	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.13033253	119	0.00109523	2.77189238	5.2228E-18	1.23820629
Within Groups	0.42673009	1080	0.00039512			
Total	0.55706262	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02435274	119	0.00020464	6.91620209	7.2371E-73	1.23820629
Within Groups	0.03195634	1080	2.9589E-05			
Total	0.05630908	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.77385826	119	0.04851982	6.10006721	1.9708E-62	1.23820629
Within Groups	8.59029924	1080	0.00795398			
Total	14.3641575	1199				

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01950734	119	0.00016393	4.83925583	9.5288E-46	1.23820629
Within Groups	0.03658443	1080	3.3874E-05			
Total	0.05609177	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	119.146482	119	1.00123094	5.97812098	7.5925E-61	1.23820629
Within Groups	180.881153	1080	0.16748255			
Total	300.027635	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.63969206	119	0.02218229	10.8655668	8.773E-119	1.23820629
Within Groups	2.20484301	1080	0.00204152			
Total	4.84453507	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.68489245	119	0.02256212	5.35415733	1.2389E-52	1.23820629
Within Groups	4.55105998	1080	0.00421394			
Total	7.23595243	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.42128522	119	0.01194357	7.19582472	2.2812E-76	1.23820629
Within Groups	1.7925755	1080	0.00165979			
Total	3.21386072	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	211.828934	119	1.78007507	9.56738084	1.635E-104	1.23820629
Within Groups	200.94121	1080	0.18605668			
Total	412.770143	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.68664178	119	0.02257682	9.30733441	1.466E-101	1.23820629
Within Groups	2.61975839	1080	0.0024257			
Total	5.30640017	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.60304729	119	0.02187435	7.96181988	9.2193E-86	1.23820629
Within Groups	2.96719784	1080	0.00274741			
Total	5.57024513	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.7665458	119	0.01484492	9.44699324	3.771E-103	1.23820629
Within Groups	1.69710257	1080	0.00157139			
Total	3.46364838	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	237.94761	119	1.99955975	9.09948588	3.54E-99	1.23820629
Within Groups	237.323796	1080	0.21974426			
Total	475.271406	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.95048704	119	0.02479401	9.52427782	5.02E-104	1.23820629
Within Groups	2.81150234	1080	0.00260324			
Total	5.76198938	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.36676755	119	0.0198888	4.22135953	2.1425E-37	1.23820629
Within Groups	5.08838611	1080	0.00471147			
Total	7.45515366	1199				

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.79891635	119	0.01511694	7.816722	5.2681E-84	1.23820629
Within Groups	2.08863762	1080	0.00193392			
Total	3.88755397	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05798162	119	0.00048724	1.73404802	6.1989E-06	1.23820629
Within Groups	0.30346317	1080	0.00028098			
Total	0.36144478	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0991658	119	0.00083333	3.74425054	6.2868E-31	1.23820629
Within Groups	0.24036642	1080	0.00022256			
Total	0.33953222	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.94586691	119	0.03315855	3.41391128	1.7874E-26	1.23820629
Within Groups	10.4897949	1080	0.00971277			
Total	14.4356618	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0105672	119	8.88E-05	2.52997319	6.0649E-15	1.23820629
Within Groups	0.03790713	1080	3.5099E-05			
Total	0.04847434	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.04348756	119	0.00036544	1.32415833	0.0150372	1.23820629
Within Groups	0.29805879	1080	0.00027598			
Total	0.34154635	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.13752325	119	0.00115566	4.62087326	8.3695E-43	1.23820629
Within Groups	0.27010267	1080	0.0002501			
Total	0.40762592	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.37602518	119	0.03677332	3.22126319	6.7205E-24	1.23820629
Within Groups	12.3290722	1080	0.01141581			
Total	16.7050974	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01048581	119	8.8116E-05	1.9537011	3.4594E-08	1.23820629
Within Groups	0.04871028	1080	4.5102E-05			
Total	0.05919609	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.06053097	119	0.00050866	1.52442865	0.00048398	1.23820629
Within Groups	0.36036893	1080	0.00033367			
Total	0.4208999	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.11603318	119	0.00097507	3.89566084	5.5955E-33	1.23820629
Within Groups	0.2703198	1080	0.0002503			
Total	0.38635298	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.79402864	119	0.03188259	2.98124068	9.9758E-21	1.23820629
Within Groups	11.5499568	1080	0.0106944			
Total	15.3439855	1199				

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00966767	119	8.1241E-05	1.66665288	2.704E-05	1.23820629
Within Groups	0.05264454	1080	4.8745E-05			
Total	0.06231221	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	575.785487	119	4.83853351	2.30382062	3.5123E-12	1.23820629
Within Groups	2268.23917	1080	2.10022146			
Total	2844.02466	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.157914	119	0.01813373	4.97042112	1.6481E-47	1.23820629
Within Groups	3.94019522	1080	0.00364833			
Total	6.09810922	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.84545808	119	0.02391141	3.40998899	2.0177E-26	1.23820629
Within Groups	7.57314043	1080	0.00701217			
Total	10.4185985	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.41295512	119	0.01187357	3.6707777	6.1934E-30	1.23820629
Within Groups	3.49339004	1080	0.00323462			
Total	4.90634516	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	339.858919	119	2.8559573	1.79177561	1.6736E-06	1.23820629
Within Groups	1721.43982	1080	1.59392576			
Total	2061.29874	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.17920357	119	0.00990927	4.1919108	5.3736E-37	1.23820629
Within Groups	2.55301605	1080	0.0023639			
Total	3.73221962	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.37688951	119	0.01997386	4.64895311	3.4961E-43	1.23820629
Within Groups	4.64013506	1080	0.00429642			
Total	7.01702457	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.33152403	119	0.01118928	4.33799556	5.6218E-39	1.23820629
Within Groups	2.78571511	1080	0.00257937			
Total	4.11723915	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	297.601426	119	2.50085232	1.19327978	0.08690066	1.23820629
Within Groups	2263.44278	1080	2.09578035			
Total	2561.0442	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.65091618	119	0.01387325	3.72554556	1.1258E-30	1.23820629
Within Groups	4.02172102	1080	0.00372382			
Total	5.6726372	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.3435651	119	0.01969382	2.89792168	1.2225E-19	1.23820629
Within Groups	7.33951178	1080	0.00679584			
Total	9.68307688	1199				

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.58847534	119	0.01334853	4.40564605	6.8154E-40	1.23820629
Within Groups	3.27225898	1080	0.00302987			
Total	4.86073431	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.49307063	119	0.00414345	2.57607344	1.6086E-15	1.23820629
Within Groups	1.73711148	1080	0.00160844			
Total	2.23018211	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.16963974	119	0.00142554	4.46972147	9.2491E-41	1.23820629
Within Groups	0.3444482	1080	0.00031893			
Total	0.51408794	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.04106666	119	0.02555518	5.38373785	5.0142E-53	1.23820629
Within Groups	5.12647483	1080	0.00474674			
Total	8.16754149	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.10164935	119	0.0008542	7.07038385	8.3977E-75	1.23820629
Within Groups	0.13047833	1080	0.00012081			
Total	0.23212768	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.56936373	119	0.00478457	2.58712058	1.1688E-15	1.23820629
Within Groups	1.99733045	1080	0.00184938			
Total	2.56669418	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.31879238	119	0.00267893	5.85930121	2.7026E-59	1.23820629
Within Groups	0.49378615	1080	0.00045721			
Total	0.81257854	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.97391418	119	0.02499088	8.20717455	1.0412E-88	1.23820629
Within Groups	3.28860381	1080	0.003045			
Total	6.262518	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.09426122	119	0.00079211	8.23731745	4.5448E-89	1.23820629
Within Groups	0.1038542	1080	9.6161E-05			
Total	0.19811542	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.77544658	119	0.00651636	2.57904954	1.476E-15	1.23820629
Within Groups	2.72878298	1080	0.00252665			
Total	3.50422956	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.31433594	119	0.00264148	5.0145944	4.2139E-48	1.23820629
Within Groups	0.5688988	1080	0.00052676			
Total	0.88323474	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.63486439	119	0.02214172	4.1409468	2.6392E-36	1.23820629
Within Groups	5.77477957	1080	0.00534702			
Total	8.40964397	1199				

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.08993563	119	0.00075576	7.16163175	6.0849E-76	1.23820629
Within Groups	0.11397159	1080	0.00010553			
Total	0.20390722	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.19651127	119	0.00165136	3.64876674	1.2283E-29	1.23820629
Within Groups	0.48878533	1080	0.00045258			
Total	0.6852966	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01172237	119	9.8507E-05	12.4681829	2.191E-135	1.23820629
Within Groups	0.00853275	1080	7.9007E-06			
Total	0.02025513	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.00087868	119	0.01681411	3.73115564	9.4534E-31	1.23820629
Within Groups	4.86691975	1080	0.00450641			
Total	6.86779843	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00601403	119	5.0538E-05	6.91950371	6.5766E-73	1.23820629
Within Groups	0.007888	1080	7.3037E-06			
Total	0.01390203	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.04265635	119	0.00035846	2.2830706	6.2076E-12	1.23820629
Within Groups	0.16956692	1080	0.00015701			
Total	0.21222327	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02068302	119	0.00017381	20.9113712	3.258E-208	1.23820629
Within Groups	0.00897652	1080	8.3116E-06			
Total	0.02965954	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.57868736	119	0.030073	5.55362642	2.8213E-55	1.23820629
Within Groups	5.84822254	1080	0.00541502			
Total	9.42690989	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00633659	119	5.3249E-05	5.56643369	1.9112E-55	1.23820629
Within Groups	0.0103313	1080	9.566E-06			
Total	0.01666789	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.08630789	119	0.00072528	1.37326948	0.00699592	1.23820629
Within Groups	0.57038948	1080	0.00052814			
Total	0.65669737	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01757859	119	0.00014772	17.2402227	3.607E-179	1.23820629
Within Groups	0.00925375	1080	8.5683E-06			
Total	0.02683234	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.04753122	119	0.03401287	5.95557548	1.4938E-60	1.23820629
Within Groups	6.16798442	1080	0.0057111			
Total	10.2155156	1199				

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00706881	119	5.9402E-05	5.75213753	6.8583E-58	1.23820629
Within Groups	0.01115306	1080	1.0327E-05			
Total	0.01822187	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	41.5112055	119	0.34883366	2.21074768	4.4228E-11	1.23820629
Within Groups	170.413094	1080	0.1577899			
Total	211.924299	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.45481751	119	0.01222536	12.2759638	1.888E-133	1.23820629
Within Groups	1.0755478	1080	0.00099588			
Total	2.53036531	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.65522786	119	0.00550612	3.01442709	3.6599E-21	1.23820629
Within Groups	1.97271509	1080	0.00182659			
Total	2.62794295	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.76381977	119	0.00641865	10.7691155	9.49E-118	1.23820629
Within Groups	0.64370614	1080	0.00059602			
Total	1.40752591	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	231.190625	119	1.94277836	10.9017284	3.602E-119	1.23820629
Within Groups	192.464951	1080	0.17820829			
Total	423.655575	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.77282664	119	0.02330106	31.1042923	3.456E-274	1.23820629
Within Groups	0.80905713	1080	0.00074913			
Total	3.58188377	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.45524366	119	0.01222894	4.83159353	1.2081E-45	1.23820629
Within Groups	2.73351915	1080	0.00253104			
Total	4.18876281	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.31991737	119	0.01109174	21.3034387	4.056E-211	1.23820629
Within Groups	0.56230744	1080	0.00052066			
Total	1.88222481	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	221.445273	119	1.86088464	9.65052471	1.89E-105	1.23820629
Within Groups	208.253486	1080	0.1928273			
Total	429.698759	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.32657052	119	0.01955101	22.8403159	3.537E-222	1.23820629
Within Groups	0.92446593	1080	0.00085599			
Total	3.25103645	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.83543587	119	0.01542383	7.0265547	2.9727E-74	1.23820629
Within Groups	2.3706835	1080	0.00219508			
Total	4.20611936	1199				

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.1899745	119	0.00999979	17.2094158	6.55E-179	1.23820629
Within Groups	0.62754998	1080	0.00058106			
Total	1.81752448	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0459685	119	0.00038629	2.0829678	1.2981E-09	1.23820629
Within Groups	0.20028782	1080	0.00018545			
Total	0.24625631	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01516445	119	0.00012743	2.84441536	6.0532E-19	1.23820629
Within Groups	0.04838496	1080	4.4801E-05			
Total	0.06354941	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.10165744	119	0.02606435	1.67754524	2.1404E-05	1.23820629
Within Groups	16.780171	1080	0.0155372			
Total	19.8818284	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00652977	119	5.4872E-05	1.46156078	0.0015519	1.23820629
Within Groups	0.04054694	1080	3.7543E-05			
Total	0.04707671	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.06222488	119	0.0005229	2.2359158	2.242E-11	1.23820629
Within Groups	0.25257214	1080	0.00023386			
Total	0.31479703	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0227261	119	0.00019098	3.79113979	1.4581E-31	1.23820629
Within Groups	0.05440413	1080	5.0374E-05			
Total	0.07713023	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.03350514	119	0.033895	1.87147245	2.5702E-07	1.23820629
Within Groups	19.5603207	1080	0.01811141			
Total	23.5938258	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0095157	119	7.9964E-05	1.64870061	3.9601E-05	1.23820629
Within Groups	0.05238124	1080	4.8501E-05			
Total	0.06189694	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.06962619	119	0.00058509	1.90338682	1.1899E-07	1.23820629
Within Groups	0.33198799	1080	0.0003074			
Total	0.40161418	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02280831	119	0.00019167	3.32939486	2.4244E-25	1.23820629
Within Groups	0.0621734	1080	5.7568E-05			
Total	0.08498171	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.91654494	119	0.03291214	1.86217035	3.2103E-07	1.23820629
Within Groups	19.0880033	1080	0.01767408			
Total	23.0045482	1199				

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00785559	119	6.6013E-05	1.51325457	0.0005985	1.23820629
Within Groups	0.04711329	1080	4.3623E-05			
Total	0.05496888	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	387.049794	119	3.25251928	4.66147972	2.3687E-43	1.23820629
Within Groups	753.563467	1080	0.69774395			
Total	1140.61326	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.88110116	119	0.02421093	12.1435035	4.153E-132	1.23820629
Within Groups	2.15323435	1080	0.00199374			
Total	5.03433551	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.66972992	119	0.00562798	3.41372857	1.7975E-26	1.23820629
Within Groups	1.78052267	1080	0.00164863			
Total	2.45025259	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.8870883	119	0.00745452	10.1894589	1.903E-111	1.23820629
Within Groups	0.79011904	1080	0.00073159			
Total	1.67720734	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	64.1138941	119	0.53877222	4.35945277	2.8784E-39	1.23820629
Within Groups	133.474091	1080	0.12358712			
Total	197.587986	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.26573277	119	0.01063641	18.9003451	9.768E-193	1.23820629
Within Groups	0.60778375	1080	0.00056276			
Total	1.87351653	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.49954086	119	0.01260118	5.49610282	1.6254E-54	1.23820629
Within Groups	2.47616881	1080	0.00229275			
Total	3.97570967	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.54685238	119	0.01299876	17.3371527	5.544E-180	1.23820629
Within Groups	0.80974428	1080	0.00074976			
Total	2.35659667	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	53.0453495	119	0.44575924	2.42118347	1.3373E-13	1.23820629
Within Groups	198.836637	1080	0.184108			
Total	251.881987	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.99072488	119	0.00832542	13.8942359	2.682E-149	1.23820629
Within Groups	0.64713546	1080	0.0005992			
Total	1.63786035	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.79899026	119	0.01511757	6.59759046	7.8647E-69	1.23820629
Within Groups	2.47468686	1080	0.00229138			
Total	4.27367712	1199				

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.37743872	119	0.01157512	11.4838243	2.573E-125	1.23820629
Within Groups	1.08858549	1080	0.00100795			
Total	2.46602421	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.69620327	119	0.01425381	4.10151901	9.0417E-36	1.23820629
Within Groups	3.75327134	1080	0.00347525			
Total	5.44947462	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01227926	119	0.00010319	3.21530888	8.0655E-24	1.23820629
Within Groups	0.03465982	1080	3.2092E-05			
Total	0.04693908	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.66072669	119	0.00555233	2.99425232	6.735E-21	1.23820629
Within Groups	2.00267394	1080	0.00185433			
Total	2.66340062	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02917328	119	0.00024515	4.44311235	2.1195E-40	1.23820629
Within Groups	0.0595902	1080	5.5176E-05			
Total	0.08876348	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.54613782	119	0.00458939	2.76173196	7.0545E-18	1.23820629
Within Groups	1.79472337	1080	0.00166178			
Total	2.34086119	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0082437	119	6.9275E-05	4.45390691	1.514E-40	1.23820629
Within Groups	0.01679801	1080	1.5554E-05			
Total	0.0250417	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.42434852	119	0.01196932	4.85672015	5.5481E-46	1.23820629
Within Groups	2.66164409	1080	0.00246449			
Total	4.0859926	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.05510756	119	0.00046309	7.67473837	2.8251E-82	1.23820629
Within Groups	0.0651665	1080	6.0339E-05			
Total	0.12027406	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.53065359	119	0.00445927	1.23676962	0.05093381	1.23820629
Within Groups	3.89402817	1080	0.00360558			
Total	4.42468176	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01076292	119	9.0445E-05	3.43835989	8.3944E-27	1.23820629
Within Groups	0.02840899	1080	2.6305E-05			
Total	0.03917191	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.7730941	119	0.01489995	6.63807581	2.3994E-69	1.23820629
Within Groups	2.42418841	1080	0.00224462			
Total	4.1972825	1199				

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.04409408	119	0.00037054	5.49857546	1.5074E-54	1.23820629
Within Groups	0.07277914	1080	6.7388E-05			
Total	0.11687322	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.28958724	119	0.00243351	2.53996765	4.552E-15	1.23820629
Within Groups	1.03473235	1080	0.00095809			
Total	1.32431958	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00654997	119	5.5042E-05	9.49420448	1.099E-103	1.23820629
Within Groups	0.0062612	1080	5.7974E-06			
Total	0.01281116	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.3039312	119	0.01936077	4.12760367	4.0035E-36	1.23820629
Within Groups	5.06580316	1080	0.00469056			
Total	7.36973435	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00670809	119	5.637E-05	5.58936365	9.5199E-56	1.23820629
Within Groups	0.01089214	1080	1.0085E-05			
Total	0.01760023	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.10492806	119	0.00088175	1.92467108	7.0781E-08	1.23820629
Within Groups	0.49477973	1080	0.00045813			
Total	0.59970779	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01073429	119	9.0204E-05	15.7766721	1.51E-166	1.23820629
Within Groups	0.00617497	1080	5.7176E-06			
Total	0.01690926	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.78162038	119	0.04018168	6.82593605	9.9551E-72	1.23820629
Within Groups	6.35754837	1080	0.00588662			
Total	11.1391687	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00881126	119	7.4044E-05	6.71333096	2.6536E-70	1.23820629
Within Groups	0.01191178	1080	1.1029E-05			
Total	0.02072304	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.25618712	119	0.00215283	1.72784814	7.1168E-06	1.23820629
Within Groups	1.34563886	1080	0.00124596			
Total	1.60182598	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00846535	119	7.1137E-05	9.91654106	1.993E-108	1.23820629
Within Groups	0.0077475	1080	7.1736E-06			
Total	0.01621285	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.07862607	119	0.03427417	5.1361323	9.9591E-50	1.23820629
Within Groups	7.20699934	1080	0.00667315			
Total	11.2856254	1199				

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01255182	119	0.00010548	4.95292607	2.8295E-47	1.23820629
Within Groups	0.02299967	1080	2.1296E-05			
Total	0.03555149	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	9.47082881	119	0.0795868	1.89595774	1.4249E-07	1.23820629
Within Groups	45.3352619	1080	0.04197709			
Total	54.8060907	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.43303345	119	0.00363894	9.45266288	3.251E-103	1.23820629
Within Groups	0.4157613	1080	0.00038496			
Total	0.84879475	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.35819469	119	0.00301004	2.14163457	2.7931E-10	1.23820629
Within Groups	1.51792588	1080	0.00140549			
Total	1.87612057	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.23302877	119	0.00195822	8.77459822	2.0679E-95	1.23820629
Within Groups	0.24102334	1080	0.00022317			
Total	0.47405212	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	59.0848751	119	0.49651156	8.44425844	1.5777E-91	1.23820629
Within Groups	63.5026135	1080	0.05879872			
Total	122.587489	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.65380226	119	0.00549414	15.0238641	8.579E-160	1.23820629
Within Groups	0.3949495	1080	0.00036569			
Total	1.04875176	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.28115669	119	0.01076602	3.85527751	1.9728E-32	1.23820629
Within Groups	3.01594487	1080	0.00279254			
Total	4.29710157	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.42732489	119	0.00359097	14.4796217	8.598E-155	1.23820629
Within Groups	0.26784144	1080	0.000248			
Total	0.69516633	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	52.2896627	119	0.43940893	6.84061386	6.4961E-72	1.23820629
Within Groups	69.3741313	1080	0.06423531			
Total	121.663794	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.50717353	119	0.00426196	9.58369538	1.07E-104	1.23820629
Within Groups	0.48028649	1080	0.00044471			
Total	0.98746002	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.14741287	119	0.01804549	4.0362254	6.9482E-35	1.23820629
Within Groups	4.82855223	1080	0.00447088			
Total	6.9759651	1199				

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.39584817	119	0.00332646	9.11655998	2.251E-99	1.23820629
Within Groups	0.39407097	1080	0.00036488			
Total	0.78991914	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.04370469	119	0.00036727	2.16441353	1.5274E-10	1.23820629
Within Groups	0.18325869	1080	0.00016968			
Total	0.22696338	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01720582	119	0.00014459	3.29529861	6.9235E-25	1.23820629
Within Groups	0.04738679	1080	4.3877E-05			
Total	0.06459261	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.06981745	119	0.02579679	1.59596249	0.0001181	1.23820629
Within Groups	17.4568816	1080	0.01616378			
Total	20.526699	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00328503	119	2.7605E-05	1.68349506	1.8824E-05	1.23820629
Within Groups	0.01770941	1080	1.6398E-05			
Total	0.02099443	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02695092	119	0.00022648	1.62641272	6.3172E-05	1.23820629
Within Groups	0.15039025	1080	0.00013925			
Total	0.17734117	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02723375	119	0.00022886	4.05509048	3.8548E-35	1.23820629
Within Groups	0.0609514	1080	5.6436E-05			
Total	0.08818516	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.00888277	119	0.03368809	2.32364887	2.0332E-12	1.23820629
Within Groups	15.6577606	1080	0.01449793			
Total	19.6666434	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00571153	119	4.7996E-05	2.98501268	8.9024E-21	1.23820629
Within Groups	0.01736534	1080	1.6079E-05			
Total	0.02307687	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.0412827	119	0.00034691	1.29318959	0.02367309	1.23820629
Within Groups	0.2897228	1080	0.00026826			
Total	0.33100549	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03995026	119	0.00033572	3.42129414	1.4228E-26	1.23820629
Within Groups	0.10597562	1080	9.8126E-05			
Total	0.14592588	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.5702891	119	0.02159907	1.4109897	0.00374961	1.23820629
Within Groups	16.5323627	1080	0.01530774			
Total	19.1026518	1199				

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00721368	119	6.0619E-05	2.34010341	1.2894E-12	1.23820629
Within Groups	0.02797685	1080	2.5904E-05			
Total	0.03519053	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	88.7095719	119	0.74545859	4.98775403	9.6494E-48	1.23820629
Within Groups	161.41439	1080	0.14945777			
Total	250.123962	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.28200452	119	0.00236979	6.42075803	1.4348E-66	1.23820629
Within Groups	0.39860851	1080	0.00036908			
Total	0.68061303	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.45086707	119	0.0037888	2.40544393	2.082E-13	1.23820629
Within Groups	1.70110091	1080	0.00157509			
Total	2.15196798	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.4884019	119	0.00410422	6.98600981	9.5905E-74	1.23820629
Within Groups	0.63449024	1080	0.00058749			
Total	1.12289214	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	68.7273681	119	0.57754091	4.31362514	1.2026E-38	1.23820629
Within Groups	144.598606	1080	0.1338876			
Total	213.325974	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.48292365	119	0.00405818	10.304621	1.036E-112	1.23820629
Within Groups	0.42532729	1080	0.00039382			
Total	0.90825094	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.37339356	119	0.01154112	3.97116604	5.2991E-34	1.23820629
Within Groups	3.13872852	1080	0.00290623			
Total	4.51212208	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.79630052	119	0.0066916	9.7813326	6.433E-107	1.23820629
Within Groups	0.73884913	1080	0.00068412			
Total	1.53514965	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	75.8654292	119	0.63752462	3.28657024	9.0548E-25	1.23820629
Within Groups	209.496993	1080	0.1939787			
Total	285.362422	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.46389192	119	0.00389825	7.6623847	3.9993E-82	1.23820629
Within Groups	0.54945186	1080	0.00050875			
Total	1.01334377	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.32801301	119	0.01956313	4.09309427	1.1763E-35	1.23820629
Within Groups	5.16191025	1080	0.00477955			
Total	7.48992326	1199				

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.87006133	119	0.00731144	6.92572047	5.4922E-73	1.23820629
Within Groups	1.14014925	1080	0.00105569			
Total	2.01021058	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.05867645	119	0.03410652	4.1451318	2.3158E-36	1.23820629
Within Groups	8.88633909	1080	0.00822809			
Total	12.9450155	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02450261	119	0.0002059	3.48432223	2.0239E-27	1.23820629
Within Groups	0.06382207	1080	5.9095E-05			
Total	0.08832468	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.5809863	119	0.00488224	2.48035059	2.5041E-14	1.23820629
Within Groups	2.1258353	1080	0.00196837			
Total	2.7068216	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02337205	119	0.0001964	3.28347082	9.9599E-25	1.23820629
Within Groups	0.06460119	1080	5.9816E-05			
Total	0.08797324	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 2 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.48846201	119	0.01250808	2.55006594	3.4048E-15	1.23820629
Within Groups	5.29740452	1080	0.004905			
Total	6.78586653	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 2 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03332275	119	0.00028002	3.47647337	2.5808E-27	1.23820629
Within Groups	0.08699187	1080	8.0548E-05			
Total	0.12031462	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 2 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.54880239	119	0.01301515	3.72710436	1.0725E-30	1.23820629
Within Groups	3.77138832	1080	0.00349203			
Total	5.32019071	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 2 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.02425334	119	0.00020381	2.94722877	2.7804E-20	1.23820629
Within Groups	0.07468519	1080	6.9153E-05			
Total	0.09893854	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 3 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.11758724	119	0.02619821	2.10458217	7.3934E-10	1.23820629
Within Groups	13.4440315	1080	0.01244818			
Total	16.5616187	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 3 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.08287826	119	0.00069646	3.9093103	3.6545E-33	1.23820629
Within Groups	0.19240542	1080	0.00017815			
Total	0.27528368	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 3 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.62389554	119	0.02204954	3.75443907	4.5768E-31	1.23820629
Within Groups	6.34275995	1080	0.00587293			
Total	8.96665549	1199				

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 3 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.03825121	119	0.00032144	3.46673503	3.489E-27	1.23820629
Within Groups	0.10013855	1080	9.2721E-05			
Total	0.13838976	1199				

Appendix D – Agglomerative Hierarchical Clustering (AHC) Results

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 1

Class	1	2	3	4	5
Objects	125	79	25	10	1
Sum of weights	125	79	25	10	1
Within-class variance	0.001	0.004	0.004	0.007	0.000
Minimum distance to centroid	0.003	0.007	0.005	0.040	0.000
Average distance to centroid	0.027	0.044	0.058	0.077	0.000
Maximum distance to centroid	0.100	0.232	0.124	0.102	0.000

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 2

Class	1	2	3	4
Objects	170	59	9	2
Sum of weights	170	59	9	2
Within-class variance	0.002	0.008	0.013	0.020
Minimum distance to centroid	0.003	0.017	0.061	0.101
Average distance to centroid	0.040	0.076	0.100	0.101
Maximum distance to centroid	0.188	0.243	0.184	0.101

Leica DM1000 – 10x – Montaged – 2 Hairs – No Filter – Shaft 3

Class	1	2	3	4
Objects	127	60	50	3
Sum of weights	127	60	50	3
Within-class variance	0.003	0.006	0.004	0.047
Minimum distance to centroid	0.006	0.010	0.003	0.014
Average distance to centroid	0.039	0.058	0.053	0.149
Maximum distance to centroid	0.211	0.259	0.157	0.222

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1

Class	1	2	3
Objects	88	139	13
Sum of weights	88	139	13
Within-class variance	0.066	0.054	0.057
Minimum distance to centroid	0.023	0.014	0.009
Average distance to centroid	0.199	0.189	0.177
Maximum distance to centroid	0.952	0.707	0.556

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2

Class	1	2	3
Objects	111	68	61
Sum of weights	111	68	61
Within-class variance	0.036	0.055	0.100
Minimum distance to centroid	0.006	0.011	0.039
Average distance to centroid	0.165	0.159	0.256
Maximum distance to centroid	0.365	1.101	0.909

Leica DM1000 – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3

Class	1	2	3
Objects	70	138	32
Sum of weights	70	138	32
Within-class variance	0.079	0.094	0.069
Minimum distance to centroid	0.019	0.016	0.033
Average distance to centroid	0.229	0.252	0.219
Maximum distance to centroid	0.835	0.667	0.627

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1

Class	1	2	3
Objects	75	154	11
Sum of weights	75	154	11
Within-class variance	0.005	0.003	0.005
Minimum distance to centroid	0.009	0.008	0.009
Average distance to centroid	0.060	0.046	0.056
Maximum distance to centroid	0.216	0.153	0.150

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2

Class	1	2	3	4
Objects	138	35	63	4
Sum of weights	138	35	63	4
Within-class variance	0.003	0.004	0.006	0.014
Minimum distance to centroid	0.006	0.019	0.014	0.045
Average distance to centroid	0.047	0.058	0.061	0.095
Maximum distance to centroid	0.115	0.142	0.219	0.135

Leica DM1000 – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3

Class	1	2	3
Objects	171	68	1
Sum of weights	171	68	1
Within-class variance	0.012	0.006	0.000
Minimum distance to centroid	0.007	0.014	0.000
Average distance to centroid	0.091	0.058	0.000
Maximum distance to centroid	0.333	0.292	0.000

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 1

Class	1	2	3
Objects	168	57	15
Sum of weights	168	57	15
Within-class variance	0.209	0.569	0.820
Minimum distance to centroid	0.054	0.033	0.029
Average distance to centroid	0.391	0.617	0.708
Maximum distance to centroid	1.126	1.782	1.700

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 2

Class	1	2	3	4
Objects	118	71	25	26
Sum of weights	118	71	25	26
Within-class variance	0.217	0.007	0.292	0.723
Minimum distance to centroid	0.022	0.016	0.050	0.026
Average distance to centroid	0.376	0.067	0.416	0.571
Maximum distance to centroid	1.555	0.390	1.484	2.399

Leica DM1000 – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 3

Class	1	2	3
Objects	46	160	34
Sum of weights	46	160	34
Within-class variance	0.795	0.185	0.451
Minimum distance to centroid	0.034	0.032	0.064
Average distance to centroid	0.679	0.341	0.545
Maximum distance to centroid	2.307	1.587	1.427

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1

Class	1	2	3	4
Objects	99	110	20	11
Sum of weights	99	110	20	11
Within-class variance	0.001	0.001	0.011	0.042
Minimum distance to centroid	0.003	0.004	0.014	0.050
Average distance to centroid	0.027	0.033	0.066	0.156
Maximum distance to centroid	0.066	0.077	0.371	0.503

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2

Class	1	2	3	4
Objects	65	164	9	2
Sum of weights	65	164	9	2
Within-class variance	0.001	0.004	0.033	0.025
Minimum distance to centroid	0.003	0.003	0.019	0.112
Average distance to centroid	0.022	0.041	0.145	0.112
Maximum distance to centroid	0.057	0.489	0.351	0.112

Leica DM1000 – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3

Class	1	2	3	4	5	6	7
Objects	21	108	59	38	7	2	5
Sum of weights	21	108	59	38	7	2	5
Within-class variance	0.002	0.003	0.001	0.002	0.013	0.061	0.001
Minimum distance to centroid	0.008	0.006	0.002	0.006	0.026	0.175	0.012
Average distance to centroid	0.034	0.039	0.035	0.031	0.090	0.175	0.031
Maximum distance to centroid	0.075	0.275	0.072	0.121	0.190	0.175	0.039

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 1

Class	1	2	3	4	5
Objects	133	15	76	14	2
Sum of weights	133	15	76	14	2
Within-class variance	0.004	0.002	0.003	0.004	0.013
Minimum distance to centroid	0.004	0.012	0.009	0.031	0.080
Average distance to centroid	0.050	0.037	0.047	0.059	0.080
Maximum distance to centroid	0.225	0.094	0.130	0.116	0.080

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 2

Class	1	2	3	4	5
Objects	50	146	14	28	2
Sum of weights	50	146	14	28	2
Within-class variance	0.003	0.004	0.009	0.002	0.001
Minimum distance to centroid	0.014	0.005	0.026	0.008	0.019
Average distance to centroid	0.047	0.048	0.082	0.037	0.019
Maximum distance to centroid	0.115	0.195	0.201	0.117	0.019

Leica DM6000B – 10x – Montaged – 2 Hairs – No Filter – Shaft 3

Class	1	2	3
Objects	112	54	74
Sum of weights	112	54	74
Within-class variance	0.001	0.011	0.008
Minimum distance to centroid	0.006	0.009	0.016
Average distance to centroid	0.034	0.084	0.079
Maximum distance to centroid	0.079	0.324	0.208

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1

Class	1	2	3
Objects	118	83	39
Sum of weights	118	83	39
Within-class variance	0.015	0.042	0.068
Minimum distance to centroid	0.006	0.012	0.022
Average distance to centroid	0.106	0.167	0.189
Maximum distance to centroid	0.261	0.676	0.877

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2

Class	1	2	3
Objects	63	170	7
Sum of weights	63	170	7
Within-class variance	0.036	0.044	0.088
Minimum distance to centroid	0.013	0.007	0.056
Average distance to centroid	0.145	0.170	0.224
Maximum distance to centroid	0.649	0.681	0.564

Leica DM6000B – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3

Class	1	2	3	4
Objects	45	61	123	11
Sum of weights	45	61	123	11
Within-class variance	0.068	0.019	0.035	0.266
Minimum distance to centroid	0.026	0.015	0.011	0.166
Average distance to centroid	0.216	0.106	0.156	0.424
Maximum distance to centroid	0.586	0.409	0.469	1.113

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1

Class	1	2	3
Objects	12	102	126
Sum of weights	12	102	126
Within-class variance	0.002	0.005	0.002
Minimum distance to centroid	0.009	0.008	0.012
Average distance to centroid	0.039	0.064	0.042
Maximum distance to centroid	0.086	0.190	0.099

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2

Class	1	2	3	4
Objects	99	62	63	16
Sum of weights	99	62	63	16
Within-class variance	0.004	0.002	0.005	0.004
Minimum distance to centroid	0.005	0.003	0.013	0.016
Average distance to centroid	0.054	0.041	0.061	0.050
Maximum distance to centroid	0.157	0.136	0.209	0.147

Leica DM6000B – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3

Class	1	2	3	4
Objects	113	88	22	17
Sum of weights	113	88	22	17
Within-class variance	0.005	0.002	0.007	0.005
Minimum distance to centroid	0.008	0.010	0.016	0.028
Average distance to centroid	0.058	0.037	0.072	0.060
Maximum distance to centroid	0.192	0.094	0.182	0.114

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 1

Class	1	2	3	4
Objects	81	57	74	28
Sum of weights	81	57	74	28
Within-class variance	0.029	0.006	0.168	0.501
Minimum distance to centroid	0.024	0.009	0.036	0.074
Average distance to centroid	0.126	0.063	0.335	0.563
Maximum distance to centroid	0.609	0.300	1.209	1.525

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 2

Class	1	2	3
Objects	5	58	177
Sum of weights	5	58	177
Within-class variance	0.411	0.195	0.027
Minimum distance to centroid	0.091	0.016	0.010
Average distance to centroid	0.441	0.353	0.125
Maximum distance to centroid	0.893	1.206	0.620

Leica DM6000B – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 3

Class	1	2	3	4
Objects	20	65	123	32
Sum of weights	20	65	123	32
Within-class variance	0.413	0.022	0.033	0.198
Minimum distance to centroid	0.061	0.027	0.019	0.045
Average distance to centroid	0.524	0.120	0.138	0.363
Maximum distance to centroid	1.387	0.434	0.668	0.931

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1

Class	1	2	3
Objects	184	30	26
Sum of weights	184	30	26
Within-class variance	0.005	0.012	0.019
Minimum distance to centroid	0.004	0.027	0.025
Average distance to centroid	0.062	0.090	0.106
Maximum distance to centroid	0.191	0.262	0.403

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2

Class	1	2	3
Objects	41	171	28
Sum of weights	41	171	28
Within-class variance	0.014	0.004	0.005
Minimum distance to centroid	0.014	0.005	0.015
Average distance to centroid	0.085	0.053	0.058
Maximum distance to centroid	0.483	0.193	0.160

Leica DM6000B – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3

Class	1	2	3	4	5
Objects	85	39	90	6	20
Sum of weights	85	39	90	6	20
Within-class variance	0.005	0.015	0.002	0.006	0.020
Minimum distance to centroid	0.008	0.014	0.007	0.013	0.022
Average distance to centroid	0.063	0.102	0.040	0.063	0.099
Maximum distance to centroid	0.195	0.268	0.098	0.104	0.386

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 1

Class	1	2	3	4
Objects	102	50	69	19
Sum of weights	102	50	69	19
Within-class variance	0.003	0.003	0.003	0.005
Minimum distance to centroid	0.003	0.002	0.007	0.008
Average distance to centroid	0.043	0.040	0.046	0.061
Maximum distance to centroid	0.162	0.124	0.170	0.131

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 2

Class	1	2	3	4
Objects	159	54	25	2
Sum of weights	159	54	25	2
Within-class variance	0.003	0.007	0.004	0.002
Minimum distance to centroid	0.004	0.007	0.010	0.029
Average distance to centroid	0.042	0.067	0.049	0.029
Maximum distance to centroid	0.208	0.256	0.122	0.029

Lomo – 10x – Montaged – 2 Hairs – No Filter – Shaft 3

Class	1	2	3
Objects	121	103	16
Sum of weights	121	103	16
Within-class variance	0.006	0.005	0.010
Minimum distance to centroid	0.006	0.004	0.011
Average distance to centroid	0.069	0.053	0.080
Maximum distance to centroid	0.211	0.235	0.220

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1

Class	1	2	3
Objects	115	107	18
Sum of weights	115	107	18
Within-class variance	0.043	0.096	0.043
Minimum distance to centroid	0.013	0.005	0.043
Average distance to centroid	0.167	0.254	0.183
Maximum distance to centroid	0.515	0.678	0.396

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2

Class	1	2	3
Objects	71	134	35
Sum of weights	71	134	35
Within-class variance	0.099	0.054	0.031
Minimum distance to centroid	0.017	0.007	0.012
Average distance to centroid	0.248	0.196	0.134
Maximum distance to centroid	0.777	0.540	0.509

Lomo – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3

Class	1	2	3
Objects	82	113	45
Sum of weights	82	113	45
Within-class variance	0.127	0.044	0.052
Minimum distance to centroid	0.007	0.011	0.008
Average distance to centroid	0.282	0.179	0.181
Maximum distance to centroid	1.391	0.451	0.598

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1

Class	1	2	3
Objects	155	47	38
Sum of weights	155	47	38
Within-class variance	0.005	0.012	0.008
Minimum distance to centroid	0.008	0.008	0.013
Average distance to centroid	0.055	0.088	0.069
Maximum distance to centroid	0.224	0.230	0.223

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2

Class	1	2	3
Objects	144	89	7
Sum of weights	144	89	7
Within-class variance	0.015	0.002	0.003
Minimum distance to centroid	0.012	0.006	0.008
Average distance to centroid	0.100	0.038	0.045
Maximum distance to centroid	0.338	0.139	0.075

Lomo – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3

Class	1	2	3	4
Objects	68	98	55	19
Sum of weights	68	98	55	19
Within-class variance	0.003	0.003	0.008	0.006
Minimum distance to centroid	0.005	0.006	0.009	0.014
Average distance to centroid	0.048	0.045	0.077	0.064
Maximum distance to centroid	0.140	0.127	0.199	0.186

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 1

Class	1	2	3
Objects	87	134	19
Sum of weights	87	134	19
Within-class variance	0.077	0.283	0.490
Minimum distance to centroid	0.014	0.017	0.034
Average distance to centroid	0.211	0.433	0.553
Maximum distance to centroid	0.908	1.486	1.060

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 2

Class	1	2	3
Objects	138	93	9
Sum of weights	138	93	9
Within-class variance	0.230	0.097	0.380
Minimum distance to centroid	0.008	0.011	0.025
Average distance to centroid	0.392	0.181	0.403
Maximum distance to centroid	1.261	1.855	1.385

Lomo – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 3

Class	1	2	3	4
Objects	10	65	62	103
Sum of weights	10	65	62	103
Within-class variance	1.179	0.256	0.104	0.050
Minimum distance to centroid	0.059	0.021	0.021	0.008
Average distance to centroid	0.860	0.407	0.250	0.172
Maximum distance to centroid	1.756	1.635	0.956	0.778

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1

Class	1	2	3	4	5
Objects	101	35	31	69	4
Sum of weights	101	35	31	69	4
Within-class variance	0.000	0.001	0.001	0.000	0.001
Minimum distance to centroid	0.002	0.005	0.004	0.002	0.014
Average distance to centroid	0.013	0.025	0.023	0.012	0.026
Maximum distance to centroid	0.036	0.082	0.065	0.024	0.042

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2

Class	1	2	3
Objects	152	84	4
Sum of weights	152	84	4
Within-class variance	0.000	0.002	0.003
Minimum distance to centroid	0.004	0.004	0.010
Average distance to centroid	0.017	0.029	0.041
Maximum distance to centroid	0.058	0.183	0.080

Lomo – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3

Class	1	2	3	4	5	6
Objects	14	107	88	6	24	1
Sum of weights	14	107	88	6	24	1
Within-class variance	0.007	0.000	0.000	0.003	0.000	0.000
Minimum distance to centroid	0.033	0.004	0.002	0.018	0.006	0.000
Average distance to centroid	0.069	0.018	0.011	0.046	0.016	0.000
Maximum distance to centroid	0.189	0.063	0.035	0.068	0.034	0.000

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 1

Class	1	2	3
Objects	119	87	34
Sum of weights	119	87	34
Within-class variance	0.003	0.003	0.009
Minimum distance to centroid	0.005	0.007	0.003
Average distance to centroid	0.040	0.048	0.076
Maximum distance to centroid	0.155	0.149	0.198

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 2

Class	1	2	3
Objects	145	67	28
Sum of weights	145	67	28
Within-class variance	0.004	0.003	0.004
Minimum distance to centroid	0.005	0.008	0.005
Average distance to centroid	0.053	0.045	0.047
Maximum distance to centroid	0.196	0.136	0.164

Olympus – 10x – Montaged – 2 Hairs – No Filter – Shaft 3

Class	1	2	3
Objects	145	94	1
Sum of weights	145	94	1
Within-class variance	0.004	0.013	0.000
Minimum distance to centroid	0.005	0.002	0.000
Average distance to centroid	0.050	0.091	0.000
Maximum distance to centroid	0.201	0.271	0.000

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 1

Class	1	2	3
Objects	156	66	18
Sum of weights	156	66	18
Within-class variance	0.064	0.095	0.109
Minimum distance to centroid	0.010	0.011	0.035
Average distance to centroid	0.208	0.250	0.277
Maximum distance to centroid	0.588	0.914	0.585

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 2

Class	1	2	3
Objects	17	131	92
Sum of weights	17	131	92
Within-class variance	0.025	0.073	0.118
Minimum distance to centroid	0.036	0.011	0.018
Average distance to centroid	0.129	0.226	0.285
Maximum distance to centroid	0.278	0.654	0.801

Olympus – 10x – Montaged – 2 Hairs – Gradientfaces – Shaft 3

Class	1	2	3
Objects	50	80	110
Sum of weights	50	80	110
Within-class variance	0.085	0.032	0.162
Minimum distance to centroid	0.025	0.009	0.022
Average distance to centroid	0.246	0.144	0.324
Maximum distance to centroid	0.592	0.497	1.002

Olympus – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 1

Class	1	2	3
Objects	110	67	63
Sum of weights	110	67	63
Within-class variance	0.007	0.007	0.004
Minimum distance to centroid	0.011	0.008	0.004
Average distance to centroid	0.070	0.071	0.059
Maximum distance to centroid	0.262	0.211	0.140

Olympus – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 2

Class	1	2	3
Objects	103	98	39
Sum of weights	103	98	39
Within-class variance	0.004	0.011	0.013
Minimum distance to centroid	0.005	0.003	0.008
Average distance to centroid	0.053	0.090	0.094
Maximum distance to centroid	0.199	0.251	0.218

Olympus – 10x – Montaged – 2 Hairs – Homomorphic – Shaft 3

Class	1	2	3
Objects	90	120	30
Sum of weights	90	120	30
Within-class variance	0.008	0.014	0.014
Minimum distance to centroid	0.009	0.008	0.007
Average distance to centroid	0.079	0.103	0.081
Maximum distance to centroid	0.188	0.278	0.377

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 1

Class	1	2	3
Objects	92	83	65
Sum of weights	92	83	65
Within-class variance	0.071	0.428	0.415
Minimum distance to centroid	0.021	0.052	0.022
Average distance to centroid	0.213	0.522	0.531
Maximum distance to centroid	0.854	2.063	2.053

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 2

Class	1	2	3
Objects	51	124	65
Sum of weights	51	124	65
Within-class variance	0.464	0.106	0.474
Minimum distance to centroid	0.075	0.019	0.022
Average distance to centroid	0.534	0.263	0.522
Maximum distance to centroid	2.386	0.876	2.293

Olympus – 10x – Montaged – 2 Hairs – Tan and Triggs– Shaft 3

Class	1	2	3
Objects	60	143	37
Sum of weights	60	143	37
Within-class variance	0.601	0.364	0.447
Minimum distance to centroid	0.039	0.028	0.126
Average distance to centroid	0.586	0.477	0.586
Maximum distance to centroid	2.714	2.277	1.349

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 1

Class	1	2	3
Objects	88	91	61
Sum of weights	88	91	61
Within-class variance	0.001	0.002	0.005
Minimum distance to centroid	0.003	0.009	0.011
Average distance to centroid	0.024	0.034	0.060
Maximum distance to centroid	0.075	0.098	0.184

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 2

Class	1	2	3
Objects	31	144	65
Sum of weights	31	144	65
Within-class variance	0.002	0.001	0.001
Minimum distance to centroid	0.010	0.005	0.007
Average distance to centroid	0.041	0.029	0.025
Maximum distance to centroid	0.085	0.076	0.109

Olympus – 10x – Montaged – 2 Hairs – Wavelet – Shaft 3

Class	1	2	3
Objects	132	107	1
Sum of weights	132	107	1
Within-class variance	0.002	0.007	0.000
Minimum distance to centroid	0.007	0.013	0.000
Average distance to centroid	0.036	0.068	0.000
Maximum distance to centroid	0.188	0.267	0.000

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 1

Class	1	2	3
Objects	485	631	84
Sum of weights	485	631	84
Within-class variance	0.006	0.010	0.012
Minimum distance to centroid	0.003	0.002	0.019
Average distance to centroid	0.060	0.077	0.096
Maximum distance to centroid	0.290	0.359	0.258

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 2

Class	1	2	3	4
Objects	305	477	333	85
Sum of weights	305	477	333	85
Within-class variance	0.005	0.012	0.002	0.016
Minimum distance to centroid	0.004	0.004	0.005	0.015
Average distance to centroid	0.053	0.091	0.035	0.115
Maximum distance to centroid	0.243	0.351	0.117	0.272

Olympus – 10x – Montaged – 10 Hairs – No Filter – Shaft 3

Class	1	2	3	4
Objects	351	331	454	64
Sum of weights	351	331	454	64
Within-class variance	0.002	0.006	0.010	0.010
Minimum distance to centroid	0.002	0.005	0.003	0.012
Average distance to centroid	0.034	0.067	0.081	0.092
Maximum distance to centroid	0.094	0.233	0.328	0.183

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 1

Class	1	2	3
Objects	489	99	612
Sum of weights	489	99	612
Within-class variance	0.198	0.065	0.058
Minimum distance to centroid	0.005	0.026	0.008
Average distance to centroid	0.328	0.225	0.204
Maximum distance to centroid	2.104	0.558	0.604

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 2

Class	1	2	3
Objects	767	391	42
Sum of weights	767	391	42
Within-class variance	0.101	0.160	0.030
Minimum distance to centroid	0.013	0.008	0.027
Average distance to centroid	0.259	0.322	0.142
Maximum distance to centroid	1.033	1.273	0.333

Olympus – 10x – Montaged – 10 Hairs – Gradientfaces – Shaft 3

Class	1	2	3
Objects	724	419	57
Sum of weights	724	419	57
Within-class variance	0.108	0.174	0.030
Minimum distance to centroid	0.015	0.006	0.014
Average distance to centroid	0.278	0.332	0.152
Maximum distance to centroid	0.835	1.309	0.388

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 1

Class	1	2	3
Objects	489	664	47
Sum of weights	489	664	47
Within-class variance	0.008	0.014	0.007
Minimum distance to centroid	0.005	0.004	0.015
Average distance to centroid	0.071	0.095	0.068
Maximum distance to centroid	0.272	0.381	0.241

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 2

Class	1	2	3
Objects	741	416	43
Sum of weights	741	416	43
Within-class variance	0.006	0.012	0.004
Minimum distance to centroid	0.004	0.004	0.005
Average distance to centroid	0.065	0.091	0.055
Maximum distance to centroid	0.288	0.275	0.168

Olympus – 10x – Montaged – 10 Hairs – Homomorphic – Shaft 3

Class	1	2	3
Objects	788	377	35
Sum of weights	788	377	35
Within-class variance	0.006	0.012	0.004
Minimum distance to centroid	0.005	0.005	0.018
Average distance to centroid	0.065	0.093	0.056
Maximum distance to centroid	0.225	0.280	0.114

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs– Shaft 1

Class	1	2	3
Objects	815	219	166
Sum of weights	815	219	166
Within-class variance	0.517	0.430	0.386
Minimum distance to centroid	0.027	0.029	0.045
Average distance to centroid	0.589	0.520	0.509
Maximum distance to centroid	2.957	2.549	1.816

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs– Shaft 2

Class	1	2	3	4	5
Objects	74	484	227	343	72
Sum of weights	74	484	227	343	72
Within-class variance	0.281	0.072	0.782	0.315	0.588
Minimum distance to centroid	0.039	0.013	0.023	0.038	0.045
Average distance to centroid	0.393	0.212	0.738	0.445	0.664
Maximum distance to centroid	2.005	0.982	2.886	1.778	1.498

Olympus – 10x – Montaged – 10 Hairs – Tan and Triggs– Shaft 3

Class	1	2	3
Objects	324	325	551
Sum of weights	324	325	551
Within-class variance	1.418	0.568	0.145
Minimum distance to centroid	0.035	0.016	0.036
Average distance to centroid	1.004	0.619	0.293
Maximum distance to centroid	3.690	2.535	1.505

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 1

Class	1	2	3	4
Objects	660	466	30	44
Sum of weights	660	466	30	44
Within-class variance	0.006	0.005	0.014	0.018
Minimum distance to centroid	0.002	0.002	0.046	0.015
Average distance to centroid	0.052	0.057	0.107	0.117
Maximum distance to centroid	0.379	0.303	0.195	0.227

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 2

Class	1	2	3	4
Objects	755	373	37	35
Sum of weights	755	373	37	35
Within-class variance	0.002	0.008	0.019	0.020
Minimum distance to centroid	0.004	0.007	0.030	0.037
Average distance to centroid	0.040	0.057	0.120	0.125
Maximum distance to centroid	0.199	0.393	0.252	0.306

Olympus – 10x – Montaged – 10 Hairs – Wavelet – Shaft 3

Class	1	2	3	4
Objects	535	568	79	18
Sum of weights	535	568	79	18
Within-class variance	0.003	0.006	0.036	0.015
Minimum distance to centroid	0.004	0.006	0.028	0.043
Average distance to centroid	0.043	0.060	0.172	0.112
Maximum distance to centroid	0.255	0.291	0.366	0.175

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 1

Class	1	2	3
Objects	899	287	14
Sum of weights	899	287	14
Within-class variance	0.003	0.004	0.025
Minimum distance to centroid	0.002	0.002	0.049
Average distance to centroid	0.041	0.049	0.135
Maximum distance to centroid	0.345	0.285	0.293

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 2

Class	1	2	3	4	5	6
Objects	418	468	16	223	68	7
Sum of weights	418	468	16	223	68	7
Within-class variance	0.002	0.004	0.015	0.006	0.011	0.002
Minimum distance to centroid	0.001	0.003	0.005	0.002	0.008	0.015
Average distance to centroid	0.033	0.048	0.095	0.058	0.084	0.037
Maximum distance to centroid	0.133	0.178	0.266	0.228	0.264	0.087

Olympus – 40x – Montaged – 10 Hairs – No Filter – Shaft 3

Class	1	2	3
Objects	753	426	21
Sum of weights	753	426	21
Within-class variance	0.004	0.006	0.019
Minimum distance to centroid	0.002	0.001	0.041
Average distance to centroid	0.045	0.063	0.119
Maximum distance to centroid	0.373	0.284	0.279

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 1

Class	1	2	3	4	5
Objects	695	10	398	25	72
Sum of weights	695	10	398	25	72
Within-class variance	0.013	0.020	0.026	0.098	0.039
Minimum distance to centroid	0.002	0.053	0.005	0.004	0.013
Average distance to centroid	0.088	0.127	0.134	0.249	0.164
Maximum distance to centroid	0.820	0.204	0.469	0.742	0.452

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 2

Class	1	2	3	4	5	6
Objects	472	536	102	14	31	45
Sum of weights	472	536	102	14	31	45
Within-class variance	0.019	0.012	0.036	0.048	0.138	0.038
Minimum distance to centroid	0.001	0.003	0.004	0.027	0.028	0.012
Average distance to centroid	0.113	0.079	0.161	0.169	0.322	0.170
Maximum distance to centroid	0.404	0.725	0.431	0.478	0.631	0.357

Olympus – 40x – Montaged – 10 Hairs – Gradientfaces – Shaft 3

Class	1	2	3	4	5
Objects	424	666	10	12	88
Sum of weights	424	666	10	12	88
Within-class variance	0.042	0.023	0.033	0.047	0.301
Minimum distance to centroid	0.001	0.002	0.027	0.009	0.011
Average distance to centroid	0.170	0.118	0.148	0.191	0.449
Maximum distance to centroid	0.580	0.720	0.353	0.308	1.422

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 1

Class	1	2	3
Objects	494	324	382
Sum of weights	494	324	382
Within-class variance	0.010	0.009	0.005
Minimum distance to centroid	0.003	0.004	0.005
Average distance to centroid	0.085	0.081	0.059
Maximum distance to centroid	0.225	0.200	0.266

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 2

Class	1	2	3
Objects	681	460	59
Sum of weights	681	460	59
Within-class variance	0.008	0.004	0.005
Minimum distance to centroid	0.002	0.005	0.012
Average distance to centroid	0.075	0.057	0.056
Maximum distance to centroid	0.267	0.230	0.229

Olympus – 40x – Montaged – 10 Hairs – Homomorphic – Shaft 3

Class	1	2	3
Objects	432	620	148
Sum of weights	432	620	148
Within-class variance	0.005	0.007	0.003
Minimum distance to centroid	0.004	0.003	0.002
Average distance to centroid	0.059	0.071	0.045
Maximum distance to centroid	0.272	0.225	0.150

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs– Shaft 1

Class	1	2	3	4	5
Objects	446	404	19	210	121
Sum of weights	446	404	19	210	121
Within-class variance	0.069	0.246	3.633	0.197	0.867
Minimum distance to centroid	0.013	0.011	0.497	0.015	0.027
Average distance to centroid	0.209	0.399	1.742	0.377	0.710
Maximum distance to centroid	0.967	1.519	3.009	1.254	3.274

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs– Shaft 2

Class	1	2	3	4	5
Objects	450	553	21	110	66
Sum of weights	450	553	21	110	66
Within-class variance	0.021	0.008	0.761	0.064	0.314
Minimum distance to centroid	0.006	0.006	0.292	0.012	0.037
Average distance to centroid	0.121	0.075	0.797	0.211	0.440
Maximum distance to centroid	0.369	0.323	1.612	0.712	2.256

Olympus – 40x – Montaged – 10 Hairs – Tan and Triggs– Shaft 3

Class	1	2	3	4
Objects	324	808	30	38
Sum of weights	324	808	30	38
Within-class variance	0.093	0.019	0.779	0.134
Minimum distance to centroid	0.006	0.009	0.052	0.046
Average distance to centroid	0.223	0.116	0.673	0.296
Maximum distance to centroid	1.738	0.569	2.096	1.056

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 1

Class	1	2	3	4
Objects	396	786	10	8
Sum of weights	396	786	10	8
Within-class variance	0.000	0.000	0.035	0.006
Minimum distance to centroid	0.002	0.001	0.070	0.012
Average distance to centroid	0.013	0.013	0.164	0.057
Maximum distance to centroid	0.178	0.074	0.313	0.152

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 2

Class	1	2	3	4
Objects	780	10	401	9
Sum of weights	780	10	401	9
Within-class variance	0.000	0.045	0.000	0.010
Minimum distance to centroid	0.001	0.122	0.001	0.038
Average distance to centroid	0.014	0.191	0.015	0.081
Maximum distance to centroid	0.050	0.320	0.127	0.195

Olympus – 40x – Montaged – 10 Hairs – Wavelet – Shaft 3

Class	1	2	3	4
Objects	240	934	8	18
Sum of weights	240	934	8	18
Within-class variance	0.001	0.000	0.037	0.066
Minimum distance to centroid	0.002	0.001	0.073	0.088
Average distance to centroid	0.015	0.017	0.162	0.237
Maximum distance to centroid	0.239	0.127	0.260	0.358

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 1

Class	1	2	3
Objects	520	650	30
Sum of weights	520	650	30
Within-class variance	0.007	0.002	0.022
Minimum distance to centroid	0.002	0.002	0.042
Average distance to centroid	0.063	0.037	0.119
Maximum distance to centroid	0.427	0.191	0.371

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 2

Class	1	2	3
Objects	515	649	36
Sum of weights	515	649	36
Within-class variance	0.002	0.010	0.008
Minimum distance to centroid	0.001	0.003	0.017
Average distance to centroid	0.036	0.077	0.072
Maximum distance to centroid	0.158	0.498	0.288

Olympus – 40x – Selected – 10 Hairs – No Filter – Shaft 3

Class	1	2	3	4
Objects	639	459	55	47
Sum of weights	639	459	55	47
Within-class variance	0.003	0.010	0.007	0.017
Minimum distance to centroid	0.002	0.002	0.007	0.025
Average distance to centroid	0.042	0.076	0.068	0.118
Maximum distance to centroid	0.173	0.480	0.225	0.251

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 1

Class	1	2	3	4	5
Objects	811	11	50	299	29
Sum of weights	811	11	50	299	29
Within-class variance	0.011	0.105	0.011	0.005	0.060
Minimum distance to centroid	0.002	0.067	0.004	0.003	0.005
Average distance to centroid	0.081	0.261	0.084	0.058	0.203
Maximum distance to centroid	0.362	0.580	0.293	0.241	0.459

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 2

Class	1	2	3	4	5
Objects	325	482	21	319	53
Sum of weights	325	482	21	319	53
Within-class variance	0.014	0.001	0.100	0.009	0.062
Minimum distance to centroid	0.001	0.001	0.030	0.003	0.012
Average distance to centroid	0.095	0.032	0.252	0.077	0.205
Maximum distance to centroid	0.426	0.111	0.700	0.337	0.521

Olympus – 40x – Selected – 10 Hairs – Gradientfaces – Shaft 3

Class	1	2	3	4	5
Objects	350	557	27	189	77
Sum of weights	350	557	27	189	77
Within-class variance	0.009	0.005	0.046	0.007	0.106
Minimum distance to centroid	0.006	0.002	0.022	0.008	0.017
Average distance to centroid	0.077	0.053	0.176	0.067	0.256
Maximum distance to centroid	0.277	0.399	0.448	0.251	0.796

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 1

Class	1	2	3
Objects	656	527	17
Sum of weights	656	527	17
Within-class variance	0.005	0.005	0.014
Minimum distance to centroid	0.002	0.003	0.009
Average distance to centroid	0.059	0.059	0.097
Maximum distance to centroid	0.207	0.378	0.235

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 2

Class	1	2	3
Objects	433	722	45
Sum of weights	433	722	45
Within-class variance	0.007	0.008	0.008
Minimum distance to centroid	0.003	0.004	0.022
Average distance to centroid	0.067	0.075	0.077
Maximum distance to centroid	0.332	0.266	0.178

Olympus – 40x – Selected – 10 Hairs – Homomorphic – Shaft 3

Class	1	2	3
Objects	466	687	47
Sum of weights	466	687	47
Within-class variance	0.004	0.006	0.006
Minimum distance to centroid	0.002	0.003	0.010
Average distance to centroid	0.052	0.059	0.066
Maximum distance to centroid	0.170	0.297	0.158

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs– Shaft 1

Class	1	2	3	4
Objects	327	823	11	39
Sum of weights	327	823	11	39
Within-class variance	0.078	0.019	0.355	0.344
Minimum distance to centroid	0.007	0.005	0.038	0.047
Average distance to centroid	0.220	0.108	0.443	0.493
Maximum distance to centroid	1.184	0.663	1.121	1.574

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs– Shaft 2

Class	1	2	3	4
Objects	566	523	21	90
Sum of weights	566	523	21	90
Within-class variance	0.007	0.042	0.454	0.162
Minimum distance to centroid	0.007	0.005	0.068	0.022
Average distance to centroid	0.070	0.165	0.554	0.334
Maximum distance to centroid	0.315	0.723	1.446	1.133

Olympus – 40x – Selected – 10 Hairs – Tan and Triggs– Shaft 3

Class	1	2	3	4
Objects	752	327	27	94
Sum of weights	752	327	27	94
Within-class variance	0.019	0.073	0.257	0.358
Minimum distance to centroid	0.010	0.017	0.021	0.024
Average distance to centroid	0.112	0.225	0.408	0.484
Maximum distance to centroid	0.610	0.901	0.977	1.905

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 1

Class	1	2	3	4
Objects	858	11	9	322
Sum of weights	858	11	9	322
Within-class variance	0.001	0.048	0.010	0.000
Minimum distance to centroid	0.000	0.114	0.016	0.001
Average distance to centroid	0.019	0.198	0.080	0.013
Maximum distance to centroid	0.263	0.324	0.209	0.064

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 2

Class	1	2	3	4
Objects	420	726	32	22
Sum of weights	420	726	32	22
Within-class variance	0.001	0.000	0.008	0.061
Minimum distance to centroid	0.001	0.001	0.010	0.038
Average distance to centroid	0.019	0.015	0.077	0.205
Maximum distance to centroid	0.119	0.099	0.211	0.556

Olympus – 40x – Selected – 10 Hairs – Wavelet – Shaft 3

Class	1	2	3	4	5
Objects	328	786	53	26	7
Sum of weights	328	786	53	26	7
Within-class variance	0.001	0.001	0.023	0.035	0.017
Minimum distance to centroid	0.003	0.002	0.016	0.060	0.047
Average distance to centroid	0.019	0.024	0.131	0.173	0.105
Maximum distance to centroid	0.122	0.236	0.314	0.281	0.234

Appendix E – Maternal Group Analysis of Variance (ANOVA) Results

Group 1 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000347	4	8.68E-05	1.231269	0.311109	2.578739
Within Groups	0.003171	45	7.05E-05			
Total	0.003518	49				

Group 1 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000705	4	0.000176	7.915068	6.41E-05	2.578739
Within Groups	0.001002	45	2.23E-05			
Total	0.001707	49				

Group 1 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.141636	4	0.035409	3.26738	0.019553	2.578739
Within Groups	0.48767	45	0.010837			
Total	0.629306	49				

Group 1 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000136	4	3.39E-05	1.878741	0.130678	2.578739
Within Groups	0.000812	45	1.81E-05			
Total	0.000948	49				

Group 2 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8.11E-05	2	4.05E-05	0.506644	0.608129	3.354131
Within Groups	0.00216	27	8E-05			
Total	0.002241	29				

Group 2 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9.75E-05	2	4.87E-05	1.527782	0.235193	3.354131
Within Groups	0.000862	27	3.19E-05			
Total	0.000959	29				

Group 2 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Energy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.009045	2	0.004522	1.453646	0.251432	3.354131
Within Groups	0.083998	27	0.003111			
Total	0.093043	29				

Group 2 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Homogeneity

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000157	2	7.86E-05	8.304669	0.001546	3.354131
Within Groups	0.000256	27	9.47E-06			
Total	0.000413	29				

Group 3 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Contrast

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.12E-05	3	1.04E-05	0.199482	0.896051	2.866266
Within Groups	0.001879	36	5.22E-05			
Total	0.001911	39				

Group 3 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Correlation

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000334	3	0.000111	6.221974	0.001625	2.866266
Within Groups	0.000645	36	1.79E-05			
Total	0.000979	39				

Group 3 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.023033	3	0.007678	0.754081	0.527241	2.866266
Within Groups	0.366529	36	0.010181			
Total	0.389562	39				

Group 3 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000119	3	3.96E-05	2.895972	0.048394	2.866266
Within Groups	0.000492	36	1.37E-05			
Total	0.000611	39				

Group 4 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000141	2	7.07E-05	0.486478	0.620073	3.354131
Within Groups	0.003924	27	0.000145			
Total	0.004066	29				

Group 4 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000113	2	5.65E-05	2.338216	0.115737	3.354131
Within Groups	0.000653	27	2.42E-05			
Total	0.000766	29				

Group 4 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.010241	2	0.00512	0.597834	0.55712	3.354131
Within Groups	0.231251	27	0.008565			
Total	0.241492	29				

Group 4 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.56E-05	2	1.78E-05	1.246848	0.303436	3.354131
Within Groups	0.000385	27	1.43E-05			
Total	0.000421	29				

Group 5 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7.68E-06	1	7.68E-06	0.04621	0.832211	4.413873
Within Groups	0.00299	18	0.000166			
Total	0.002998	19				

Group 5 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000115	1	0.000115	5.779773	0.027196	4.413873
Within Groups	0.000358	18	1.99E-05			
Total	0.000472	19				

Group 5 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.09404	1	0.09404	7.415079	0.013951	4.413873
Within Groups	0.228281	18	0.012682			
Total	0.322321	19				

Group 5 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.62E-06	1	4.62E-06	0.203746	0.657105	4.413873
Within Groups	0.000408	18	2.27E-05			
Total	0.000413	19				

Group 6 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Contrast

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1.65E-05	2	8.23E-06	0.050666	0.950687	3.354131
Within Groups	0.004387	27	0.000162			
Total	0.004403	29				

Group 6 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Correlation

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000431	2	0.000215	29.60049	1.56E-07	3.354131
Within Groups	0.000196	27	7.28E-06			
Total	0.000627	29				

Group 6 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Energy

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.002229	2	0.001115	0.20993	0.811951	3.354131
Within Groups	0.143371	27	0.00531			
Total	0.145601	29				

Group 6 – Olympus – 10x – Montaged – 10 Hairs – Shaft 1 – Homogeneity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7.92E-05	2	3.96E-05	3.779642	0.03571	3.354131
Within Groups	0.000283	27	1.05E-05			
Total	0.000362	29				